Visual Communication: A Methodology for Measuring Management Intention and Shopfloor Acknowledged Meaning.

Sajid Saddiq.

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Abstract

The aim of this research study was to explore the management intended and subsequent acknowledged meaning of visual communication found in organisations, specifically those used in shop-floor contexts. In doing so the intention was to generate new insights into the concept and use of visual communication.

In organisations, visual communication is said, for example, to contribute to and sustain continuous improvement (Jaca et al. 2015), but how can this be known unless it can be measured in some way? To date, due to the fragmented understanding and lack of holistic approaches to investigating visual communication, this remains a subject that is empirically under-theorised and detached from real world professionals and contexts.

To access the intended and perceived meaning, the Shannon & Weaver (1949) Communication model has provided the necessary conceptual framework. Although originally created to depict telegraphic communication, it is said to be representative of all forms of communication and was used successfully to theoretically underpin this research. This structure, through a neo-positivist case study design, has enabled the exploration of visual communication in a manufacturing environment. Using a number of qualitative and quantitative data collection methods, based on the Repertory Grid Analysis design (George Kelly), enabled the themes that are motivating visual communication to be operationalised. These methods have put at centre stage the motivation of those involved in the acts of visual communication by empowering their voices. This has been done whilst retaining a strong focus throughout on practice based issues to ensure the utility in future for researchers and managers to make sense of the usefulness of real world visual communication.

This research has demonstrated how individual managers are bound by the overall imperatives for mass production environments, using visual communication to affect control of issues such as capacity, inventory and customer demand. However, what has also been demonstrated is their further orientation towards specific requirements based on the contingency of their sub-environments, i.e. safety, profitability, supply chain issues, etc.

The findings of this thesis, in relation to enabling the measurement of visual communication meaning within its situated context, contributes to both organisational and management theory. The ability to measure what individuals interpret from different visual communication in comparison to the intended meaning, is a first step to focusing a scientific light on its use and usefulness. Doing this using a direct form of analysis for evaluation, without recourse to specialist statistical analysis, also lends itself to being practised by managers in the future.

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Candidate's Statement

Declaration: I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged. I would to acknowledge the support from Alastair Bissett (Development Methods Manager at Automotive UK), who provided invaluable help with the Fisher Exact Match test, p-value calculations and generally with guidance about how to structure the data analysis.

The aim and objectives of this research were:

Aim:

- To measure the level of correlation between the intended and interpreted meaning of visual communication.

The objectives to achieve the above aim were:

- To extract (elicit) psychological constructs from managers who author the visual communication utilised on the shop-floor.
- To use these psychological constructs to create a measurement instrument to enable an exploration of the intended and interpreted meaning of visual communication.
- To conduct this research using methods which were consistent with a neo-positivist approach.

Sajid Saddiq

1 Introduction

1.1 Research Aim and Objectives

The aim of this research was to correlate the intended and interpreted meaning of visual communication. The objectives were to do this within the organisational setting, directly from those involved in the communication acts themselves.

Visual communication is used in manufacturing organisations to support a variety of needs. At the level of the manufacturing process it can be designed to highlight problems in visual forms to enable those operating it to be aware and take necessary actions (Wojakowski 2015, Galsworth 2004). At another level the visual communication supports managers in their need to inform and manage the activity of those operating the shop-floor (Jaca et al. 2014). The stage for this research is this second level, this hierarchical communication between those individuals (operators) that are operating the manufacturing equipment which is producing the products that the organisation is selling and those (managers) that are directly responsible for these operators.

What takes place here at the 'technical core' of the organisation (Thompson 2004) is a communication between two groups. On one side there are managers who author visual messages. On the other side there are operators, who are the intended audience. Within this shop-floor context this research has specifically explored the correlation of visual communication meaning, i.e. comparing the message as it was intended by managers, and the subsequent interpretation of this message by the operators.

Having set the scene for this research this chapter now introduces the aims, objectives, and research rationale from an academic, methodological and practice based perspective followed by a short introduction to the case study company. The final part of this chapter states the intended contribution of this research and introduces the structure of this thesis.

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- To conduct this research using methods which were consistent with a neo-positivist approach.

It is important to mention here that the scope of this research was purposely limited to intended and interpreted meaning of visual communication. The rationale for this is further discussed in the next chapter.

1.2 Research Rationale

This research was warranted because visual communication is used in organisations and has been said to be important (Bititci et al. 2016, Jaca et al. 2014). However currently there does not seem to be a scientific way of comparing and contrasting the intended and interpreted meaning. This thesis helps to close this gap in understanding in respect of visual communication.

In organisations visual communication contributes to and sustains continuous improvement (CI) practices (Kattman et al. 2012, Galsworth 2004, Mestre & Strom 1998). For example, simple binary colour coding can be used to convey the status of machines, manufacturing lines, departments or indeed whole organisations at a glance (Parry & Turner 2006). In doing so it can make visual what otherwise would need to be verbally communicated. However knowing what works from a practical perspective is not the same as knowing how or why it works from a scientific perspective. This deeper understanding can only come about through a more theoretically informed exploration. Having reviewed literature in an attempt to gain a deeper understanding, it was clear that this is an area that is still relatively under explored (Bartmanski 2014, Jaca et al. 2014).

For mass production organisations there are some key shop-floor imperatives that help to satisfy the need for a stable, efficient and predictable work environment (Thompson 2004). Visual communication is seen as an important component (Fullerton et al. 2014, Liker 2003) in the overall mix for achieving this stability as it can provide immediate, simple and clear information to those that need it. This in turn can enable people to take timely action (Wojakowski 2015). However, despite the shop-floor having a high density of visual communication (Jaca et al. 2014), how can we know it is actually useful? Do we know which forms of visual communication are better at the job of communicating than others? Which ones could be removed without consequence, perhaps even serving to improve the clarity of what remains? If the assertion is correct, that stability is critical for profitable mass production (Thompson 2004) then it is important to gain more knowledge about those acts of communication that contribute to this.

Visual communication as a technology has become increasingly available in organisations (Bell et al. 2014). This is partly due to advances in information technology, greater familiarity of its use, reduced cost and increased availability (Bell et al. 2014). It is used in organisations to serve a variety of needs. Examples relevant to this research are;

> "...strategy development and implementation... performance measurement and review…people engagement...internal and external communication... enhance collaboration and integration... development of a continuous improvement culture..."

(Bititci et al. 2016, p1)

Part of the reason for its widespread use is that it has the potential to be a very powerful form of communication. Arguably "at the first look you see the most important points…" (Mutanen 2016, p25 referring to Neurath). However, a systematic understanding of how it can be used and particularly how it is being interpreted is lacking (Jaca et al. 2014, Bresciani & Eppler 2009). It was this interest in, and concern with, the use of visual communication in a manufacturing shop-floor environment that led me to my central question “can the intended and perceived meaning of visual communication be effective?"

Trying to access the understanding between managers and operators of any given visual communication is to ask what was intended and subsequently understood as having been communicated through that communication. By providing the means of establishing the correlation between the intended and interpreted meaning of visual communication can in turn provide ways of improving its usage by those managers who are tasked to author such communication.

To access this 'comprehension' I have utilised the communication systems model devised by Shannon & Weaver (1949). This model was originally based on the transmittal of information through communication channels such as telegraphy. According to the original interpretation of this model, issues of communication are considered as engineering problems, independent of the semantic aspects of that communication. However, its authors argued that their model was applicable to all human communication and it has been used to theoretically underpin this research.

My interest in visual communication stems from having worked in manufacturing organisations for many years and encountering numerous examples of it in use. I have considered the benefits of using it alongside and instead of other forms of communication and have often thought of the possibility to measure its communicative power. My concern was that if visual communication is used in organisations, without considering the correlation between communicator and those being communicated to, then the effectiveness of that visual communication is questionable. If organisations only copy and paste what has worked in the past, this does not guarantee that it will work in the future (Hamel 2009) or even that it is the right solution for now (Bresciani & Eppler 2009).

1.3 Background of Case Study Company

The research was conducted within a UK based organisation, established more than 100 years ago. In this research I have referred to it as Automotive UK. At the time of conducting the research it had +400 employees with a turnover of c.£60m (2015). It manufactured a narrow range of products for cars, trucks, and railway applications. The product portfolio consisted of more than 500 part numbers that had been divided into a number of different dedicated production areas across the site, also referred to as ‘value streams’ (Liker 2003).

I had available a choice of sites in various regions of the world including several based in the UK. The selection of a native English speaking site was driven by the research design and methods which I will discuss in the research methods chapter. The reason for selecting this particular site within the UK was that it was relatively developed along its Lean journey. My curiosity in relation to visual communication stemmed from my involvement in the Lean development of sites and I was particularly interested to understand how this was being used in such a mature environment.

1.4 Contribution

The Shannon & Weaver (1949) model is depicted as a symmetrical process model. It depicts communication as requiring an exchange between two cognitive systems, and the intended and interpreted meanings cannot be accessed by concentrating on just one end of these cognitive processes (Lenski 2010). Based on this conceptualisation this research has operationalised the Shannon & Weaver (1949) model in a novel way to access the intended and interpreted meanings within the situated socio-cultural context (Seppanen & Valiverronen 2003) of an organisational setting. The use of this model to underpin this research has ensured that the cognitive to cognitive system symmetry mandated by the definition of communication is respected. I have explored this conceptual model in the literature review and discussed in detail how it informs the research design in the methods chapter.

This research has looked beyond the simple codification of 'best-practices' in respect of visual communication. Instead it has explored the intended meaning of visual messages and their subsequent interpretation. I have identified and demonstrated a design and methodology which closes a gap in our management and organisational practices and makes available a means of accessing this correlation. This research is important because enabling the measurement of this correlation, between intended and received communication meaning, is a first step to focusing a scientific light on this interaction. In effect it starts to treat visual communication as an organisational technology, and in doing so it provides a means of fine tuning visual communication for specific contexts. The identification of problems and the proposing of improvements related to visual communication require the capacity to be able to measure it.

Socio-technical system theory is an approach that looks at the design of organisations (Cummings 1978). In the context of this research it considers the manufacturing technology and the human relations as interrelated dependant variables whereas previously technology alone would largely determine the social conditions (Ropohl 1999). From an academic perspective it focuses on developing a deeper understanding of the relationship between "...people, technology, and environment…" (Cummings 1978, p625). From a management perspective the aim of socio-technical systems is to foster improved productivity and human enrichment by attending to the respective needs of the task as well as the social needs of individuals and groups (Miller & Rice 1967). The emergence of socio-technical theory was in fact initiated by these managerial needs; to identify the "...diffusion of innovative work practices and organizational arrangements which did not require major capital expenditure but which gave promise of raising productivity" (Trist 1981, p7).

A number of different socio-technical models exist. Subjects as diverse as Information systems (Lyytinen & Newman 2008, Newman & Robey 1992) to environmental problems (Geels 2010) have been studied. Depending on the topic, the appropriate unit of analysis can be the primary work system, the whole organisation, or the macro social perspective (Trist 1978), whereas in other studies it has been the national, sectoral, or regional levels (Geels 2004). In these different studies the independent factors used to characterise the technical or social aspects varies. Lyytinen & Newman (2008) propose a model characterising four key elements of structure, technology, task, and actors, that are said by them to be interrelated, resulting in any given socio-technical state. This simple and elegant socio-technical view serves to highlight the importance of this research. This is because visual communication is used as an interface between people, their tasks, and the technology, all of which takes place in a particular organisational structure.

Despite my focus on visual communication in the context of shop-floor production environments, the use of visual communication technologies is encouraged through continuous improvement (Murata & Katayama 2010) and Lean thinking (Galsworth 2004) right across the organisation (Murata & Katayama 2010). This research has identified methods that are applicable to the measurement of visual communication across the broader organisational areas and perhaps different organisational types (Thompson 2004).

Visual communication is still an emerging field of research and as a result there are diverse schools of thought about how to conduct research within it (Pauwels 2006, Smith et al. 2004). The majority tend to privilege the researcher with interpreting signs for meaning or identifying suitable taxonomies for their classification (Jappy 2013). To remain true to my neo-positivist orientation, my methodology was designed to measure visual communication through the involvement of those that are creating and interpreting it. These methods were designed for the exploration of visual communication within its situated context, which can be used in the future as an accessing technology by practicing managers.

1.5 Structure of the Thesis

Following this introduction, chapter two is a critical review of the current literature related to issues of visual communication. Here I have explored literature particularly related to mass production environments and the imperatives driving the need for visual communication in such situations. I have explored applicable taxonomical frameworks and their specific focus. I have also added a justification for the scope of this research. Finally, I have looked at the features of communication models and identified one which is suited to this research and more generally to visual communication.

In the research design chapter (chapter three) I have explained how a case study approach using a Repertory Grid Analysis design (George Kelly) has been used for accessing the intended and interpreted meanings in relation to examples of visual communication images. The particular images used in this research were selected by those using them, from examples they encountered and selected on a manufacturing shop-floor. This methodology has enabled the meaning given by individuals to visual communication to be measured, and in turn has enabled a correlation to be made between the understanding of those images by those authoring them and those subsequently interpreting them.

In the same chapter I have provided extensive details about the use of the research methods to gather the data. The methodology has involved several dependant steps which were linked together and I have explained clearly the need for this chain of data gathering to enable the correlation to be made.

Having completed the data gathering phase, in the findings chapter (chapter four) I have presented the results of my investigation and shown how the methods applied were used to evaluate the correlation. I have used this to reveal interesting findings about the use of visual communication at Automotive UK.

In chapter five I have discussed and reflected about how the findings inform and contribute to the current debates about the use of visual communication in organisations. This is particularly in relation to shop-floor imperatives and how visual communication is used in the context of control. I have also considered the research design and methods and how these inform the use of this approach for future research.

In the final chapter (chapter six) I have conclude with a summary of what has been achieved through this research and how it can contribute to the wider issues relating to visual communication. I have also highlighted the areas that this research has contributed to in relation to organisational and management theory and areas where further related research is warranted.

2 Literature Review

I have divided this literature review into eight sections. In the first section I have clarified the scope of this research, explaining why the autonomous work group is an important unit of study, as well as an explanation about why I have considered issues such as operator resistance to communication messages as being out of scope.

In the second section I have provided a working definition for visual communication, highlighting how it is premised on several foundational elements. This definition is relevant to this research because it both defines what it is that is being researched and also in establishing the relevance of the conceptual model used in the research design.

In the third section I have looked at the generic types of communication models to understand their usefulness to my research aims. I have then focused on communication models based on a ‘process’ perspective, specifically the Shannon & Weaver (1949) model that has been used to conceptually inform the research design.

The fourth section is a focus on exploring visual communication taxonomy models. In particular I have looked at those that are relevant to a shop-floor environment. I have done this to see what common features exist between the various models and what they focus on. This aids an understanding of what is motivating the need for the use of visual communication and as will be shown later, it supports the methods used in this research.

In the fifth section of this chapter I have explored the theoretical perspective of organisations that has been used in this study, specifically considering the organisation as a cybernetic system (McAuley et al. 2014). This sets the context for the broad and important role that visual communication plays in relation to the shop-floor and the organisation as a whole.

In the sixth section I have identified factors that define organisational contingencies in the use of visual communication, and how the characterisation of mass production environments helps to identify the usage of visual communication in the organisation.

The seventh section is an exploration about how control is affected in organisations and how visual communication contributes to issues of control on the shop-floor.

The eighth section is a review of the links between visual communication and performance management systems, particularly at the shop-floor level. This section makes the connection between visual communication, strategy deployment (Lee & Dale 1998) and feedback (cybernetic) processes.

The final section is a summary and conclusion of what has been learnt from the review of literature.

Note that in section five I have also developed the theme of socio-technical systems and why it is important to temper a strictly task focused view that emerges from the cybernetic systems. It is important to note that the socio-technical perspective is encapsulated more broadly by the literature review as a whole. As mentioned earlier the model proposed by Lyytinen & Newman (2008) characterises four key socio-technical elements; structure, technology, task, and actors, and are said by them to be interrelated. These four elements permeate throughout the literature review. For example section five and six explore the structure of the organisation and the role of actors within it. However in identifying that the manufacturing equipment is structured according to a 'single piece process layout', this also highlights contingent impacts on technology and tasks. Similarly section eight identifies the importance of communication systems in the context of organisational structure, and this cannot be considered in the absence of the organisational actors, or the object of communication which are related to the tasks and technology.

2.1 <u>Scope</u>

This research looks at the technical core (Thompson 2004) of the organisation, to understand the consistency between the management intended and operator acknowledged meaning of visual communication. It takes visual communication used by managers and the meaning given to these, and compares it to the meaning given to the same visual communication by operators, i.e. comparing the message as it was intended by managers and the subsequent interpretation of this message by the operators.

My research was not aimed to access what was done once any given visual communication message had been received. For example I did not explore issues such as resistance by the operators to the attempts by managers to exercise control (Watson 2006). Also I did not look at issues of reflexivity on the part of the participants, either managers or operators (Bagnoli 2009). For several interrelated reasons which I have discussed below the scope was purposely limited to measuring interpretation by the operators but not the subsequent action.

I felt it was initially important to understand the interpretation of visual communication by managers and operators before it is possible to speak about resistance. Without checking if operators actually had interpreted a given communication in a consistent way to its intended meaning it would be difficult to makes claims about the basis of their subsequent action, i.e. was perceived resistance intentional or was it in fact based on a misunderstanding.

The very use of the term resistance, referring to the operators, also highlights an important characteristic of their respective position in the organisation, and relationship to those whose intentions they are potentially 'resisting'. Automotive UK had a typical mass production organisational structure (Liker 2003), and can be described as a bureaucratic hierarchy (Jaques 1990). In such an environment the managers have a privileged position. This is in terms of their formal authority which provides them the opportunity to craft and implement visual communication, as well as providing other levers of control that respectively impacts the ability of operators to resist or accede to the exercising of that authority. The necessity to characterise this web of control to contextualise the resistance by operators, was considered by me to be too broad, and outside the scope of this research.

A further reason for excluding operator resistance is that my perception was that both parties accepted the need and legitimacy of using visual communication. The manager’s use of visual communication is driven by the need for stability and standardisation in the relatively closed environment of a mass production shop-floor (Thompson 2004). The slow to change nature of this environment allows the legitimacy of visual communication to be built and settled. This is consistent with the ‘representative bureaucracy’ identified by

Gouldner (1954) where both management and workers agreed about certain rules, which they both enforced, generally in the absence of any tension.

Probably the most important reason why resistance at an individual operator level has been considered out of scope is related to the issue of the unit of study. I will introduce in the research methods chapter that the focus has been at the value stream level, i.e. work-group (Liker 2003, Cummings 1978). My interest in the use of visual communication has stemmed from my involvement in the deployment of Lean methods in organisations. Lean production has been described as an integrated socio-technical system (Shah & Ward 2007). This perspective is based on seeing production systems as a web of connections between the social and technical parts of the organisation. "The former consists of the equipment and methods of operations used to transform raw materials into products or services; the latter includes the work structure that relates people to the technology and to each other" (Cummings 1978, p625). An important consideration when deciding the unit of study has been the consideration of the role of visual communication within these value stream teams. Within the socio-technical perspective, the unit of study, i.e. the building block, is the work group (Cummings 1978), and by implication not the individual operator level.

At Automotive UK the differentiated production areas have been designed to be relatively autonomous. This is both in terms of manufacturing equipment, as well as with sufficient cross functional integration that the groups can largely self-regulate (Cummings 1978). It is the role of visual communication to enable this self-regulation; the use of visual communication in the context of management control, which makes it an important area of study. The purpose of this research was not to delve into an individual, ideographic level of study about the individual experience of operators, but consistent with socio-technical theory, was to explore the experience of the workgroup, and at this nomothetic level, the intended and interpreted meanings of visual communication.

2.2 Visual Communication Definition

A starting point for this research is to define what visual communication is. It is useful to start by looking at a working definition for 'communication'. However, this is built on a number of other elements that must be introduced. To do this it is necessary to connect some terms together as they are all involved in the communication as a process. These terms are knowledge, information, data and communication (Lenski 2010).

In speaking about how knowledge is shared between individuals, Lenski (2010, p111) stated that "... information may best be described as communicated knowledge that is external to a cognitive system and requires an appropriation process to accommodate it in a specific setting". Here the term ‘information’ is used to describe the shaping of knowledge so that it can be shared and understood by others. The creation of this information is not self-referential but equally it cannot reside outside of cognitive systems (Lenski 2010). This is because it must be both created and interpreted by cognitive systems to be considered information, or otherwise it remains only data. This leads to a useful basic definition of communication. It is a process of shaping knowledge to information by one cognitive system, the transfer through some medium and the subsequent interpretation by a second cognitive system (Lenski 2010). It is the very fact that two cognitive systems are involved, and there is a shaping of the information for the benefit of information transfer that gives rise to it being considered communication, i.e. an interaction between two people (Keeney 2009). This definition of communication recognises that the cognitive systems of sender and receiver are separate entities from each other and from the artefacts of communication that might be necessary in any given context. Separation of the elements that make up communication is particularly useful as a definition, given that this research was aimed to explore the relationship between the intended and interpreted meanings.

Building on the ideas of communication from above, and introducing the visual dimension, a fuller definition is provided by Keeney (2009) who stated that visual communication is a social process. It is social because it involves the interactions between two people, where typically one person at least cares to communicate a message to another (Keeney 2009). It is a process because it consists of a series of communication acts or exchanges where one person is using symbols to send a message and the meaning of this message is understood in some way by the other and they are able to respond (Keeney

2009). The description of it as a process will be further explored in the next section where I have introduced the conceptual model used in this research. Finally the visual aspect of the communication is in relation to the way that the communication is affected, i.e. by objects such as "...drawings, paintings, photographs, videos, films, computer graphics, animations, and virtual reality displays" (Keeney 2010, p1).

2.3 Communication Models

Having defined visual communication, in this next section I have provided an overview of different types of communication theories available and have specifically highlighted and explored the one used to underpin the conceptual model used in this research. The introduction of the conceptual model at this stage is relevant in that it further helps to define visual communication and sets the scene for the review later in this chapter relating to the use of visual communication in organisations.

Communication models vary depending on their underpinning theories and can be characterised into two broad types. The first type are those derived from the worlds of information technology (Kelly 2014, Baldwin & Roberts 2006), and are referred to as Process Models. These are based on the perspective of communication as the transfer of a message, i.e. a linear process where some message is transferred from point A to point B (Kelly 2014, Baldwin & Roberts 2006). The second type are based on the study of linguistics, and are referred to as Semiotics Models (Kelly 2014, Baldwin & Roberts 2006). These consider communication as the production and exchange of meaning, recognising that a single message can mean different things to different people; meaning is influenced by the socio-political environment of the communication (Baldwin & Roberts 2006).

The key difference between these two types can be regarded as the amount of agency that they afford the recipient of the communication (Kelly 2014). I have discussed each approach below and have explained the rationale for selecting the particular approach that I have adopted.

Within semiotics, there are two traditions. One tradition, developed by Ferdinand de Saussure, sees semiotics as structure (Baldwin & Roberts 2006).

The other approach, developed by Charles Peirce, considers semiotics as a social process (Baldwin & Roberts 2006). These two views are not incompatible (Baldwin & Roberts 2006), and in fact have a great deal in common. Both models accept that there is an overall lack of correspondence between a sign (visual communication) and the effect that this can have, which depends on social and cultural conventions and contexts. In this following discussion I have elaborated on the Peircean view highlighting one or two differences between this and the Saussure theory.

Peirce developed a model relating to the meaning making of signs, called the Peircean Semiosis model. This triadic model includes the object, the sign, and the effect of the sign on someone. See Figure 2-1 below which shows a "...three way relation between the sign, the 'absent' entity which it represents, termed its object and finally the effect the sign produces, its interpretant" (Jappy 2013, p2). Signs are said to be "motivated" (Jappy 2013, p6) by their respective object in some way, shown by the arrow between the object and sign. The object is not restricted to physical things, so in this respect it is similar to Saussure’s theory, but in the Peircean model the object is linked to the meaning of the sign, represented by the dotted line (which is missing from the Saussure model).

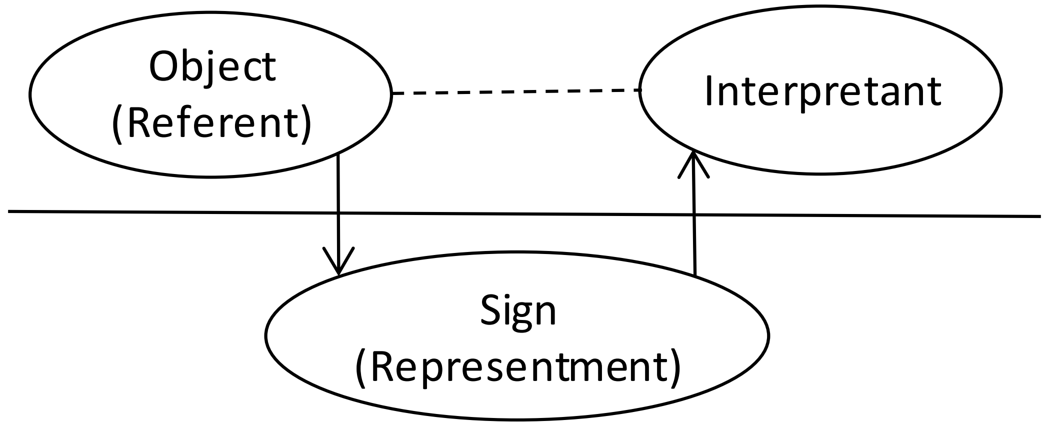


Figure 2-1 – Peircean Semiosis Model

(Jappy 2013, p6)

An important and interesting representation within this model is the solid horizontal line across the middle, which shows the separation between the thoughts in the minds of individuals and the real (physical) world (Jappy 2013). The sign is the only aspect physically available for inspection, but it is insufficient within the theory of visual semiotics to consider only this. The object and interpretant must also be considered, despite the fact that they are not physically available for inspection, being within the minds of someone who created the sign or the effect the sign has on someone (Jappy 2013). This results in this triadic nature of object, sign and meaning (Jappy 2013).

Within semiotics theory the act of communication is viewed as a "production and exchange of meaning" (Fiske 2011, p2) with the receiver seen as "...a cultural and social agent in the communication" (Kelly 2014, p213), who brings their own different cultures to bear on the interpretation of meanings within a given communication (Fiske 2011).

Importantly, Peirce argued that all thinking is dialogic in form (Jappy 2013) and that internal reflection of meaning, for example of visual communication, is socially influenced. Peirce also argued that semiosis (the act of interpretation) is not limited and the interpreter is free to successive interpretants (Jappy 2013), i.e. reinterpretation of the meaning of signs. This dialogic nature is important if we consider the use within a group, such as a shop-floor production team. In such a context there is clearly the opportunity for the history of prior usage to exert an external influence on the meaning making of a given sign. For example this could be related how certain production imperatives have been emphasised, or the physical and social context of the production areas have contributed to the meaning of the sign.

Within the semiotic theory perspective the focus is typically on the text (visual communication) itself and how the reader interacts and negotiates with it to establish meaning. By the same token the message sender and their respective motivation for the message "declines in importance...the emphasis shifts to the text and how it is read" (Fiske 2011, p3). This highlights an important weakness of this type of model in the context of this research. Semiotics is considered suitable for interpretivist, post-positivist or positivist research (Cuncliffe 2010), but the focus is more on the message and its interpretation and potentially misses an important element of the overall communication, i.e. the motivation of the sender of the message.

My research aim was to understand the intended and interpreted meaning of visual communication. It was important to consider the motivation and intention in the minds of the managers in their usage of particular shop-floor visual communication signs as well as the subsequent interpreted meanings. I wanted to understand from those charged with the responsibility to affect control of the shop-floor about how they consider particular signs, what is the intention of those signs, and to then understand from the target audience of these signs how they interpret their meaning. It was because of this lack of end to end (intended and interpreted) communication emphasis in the semiotic theory models that I decided against their use in this research.

In contrast the process model effectively defines communication as the transmission of messages (Fiske 2011). This is exemplified by the Shannon & Weaver (1949) communication systems model. As the name suggests, this sees communication according to a systems perspective (Jones & Kovac 2003). This model originated from theory developed to illustrate how information is transmitted using communication channels such as telegraphy (Baldwin & Roberts 2006). However, it is argued by its authors to be applicable to all human communication.

In Figure 2-2 below, the linear nature of the model, moving from left to right, is evident. All process communication models are said to consist of five basic elements (Watson & Hill 2012). Below I have explored each of these elements and identified how they relate to visual communication in an organisational setting.

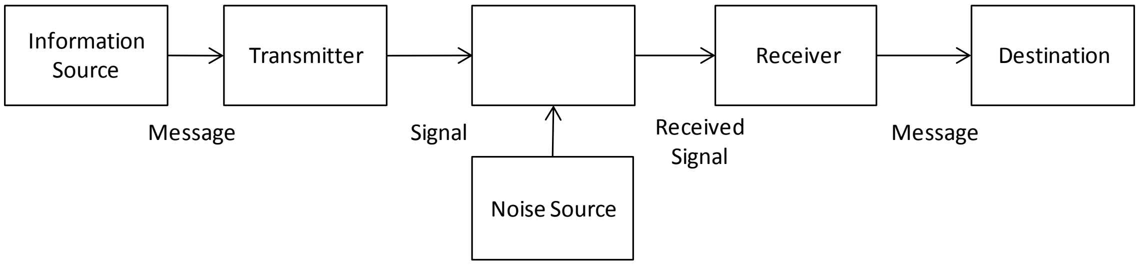


Figure 2-2 – Shannon & Weaver (1949) – Communication System Model

(Shannon & Weaver 1949, p4)

The first element is the information source (the sender) who determines the message to be sent, and is motivated to select one particular message from all possible messages. This point is relevant to this research because the aim was to access the motivation behind this intentional message transmittal as opposed to an unwitting emergence of meaning or motivation from the interaction with a message and the recipient. This identification in the model of the information source, as distinct from the message, recognises an agency and motivation (Fiske 2011) for communication.

In the case of visual communication for organisational use, the identification of the source and their role in the organisation can help to provide some predictability about the possible messages that are being communicated. Their agency may be limited because of organisational imperatives, departmental policies, protocols and standards about what and how they are able to use visual communication. This effectively means that the messages that the information source chooses to transmit are not 100% predictable, but it is also not totally surprising. From a research perspective these considerations help to provide some theoretical basis for the motivation behind the message that the visual communication is being used to convey.

The message is identified as a flow of data in the model. There is recognition that there is a message in the mind of someone before it has been converted into a visual communication format. This separation in the model is suggestive that an inspection of the visual communication alone could not be thought to faithfully contain the message that was intended. This is because by the stage the message becomes a visual communication it has already been subjected to translation, i.e. "...must be sampled, compressed, quantized and encoded, and finally interleaved...to construct the signal" (Shannon & Weaver 1949, p7).

The ‘message’ behind any given visual communication can be relatively inaccessible because of the time and place separation between the motivation for creating a visual communication and the physically available artefact. However, there are aspects about the nature of any particular organisational environment that could be helpful. An example of this could be if there are relatively few, slow to change, key imperatives dominating that particular type of organisational environment (Schmidt 2005). The effect could be that the overall meaning of the message behind a given visual communication would still be accessible, because it was still relevant and had not diminished.

As mentioned, messages have a level of predictability because they are themselves dependent. For example the core technology operating within the organisation to a large extent determines the range and nature of issues that have to be communicated (Perrow 1967). This predictability can make the message more or less resilient to communication, resulting in errors and therefore potential ineffectiveness. The organisational socio-cultural context (Seppanen & Valiverronen 2003) alters the obligation it places on those engaged in transcribing visual communication in that they are aware of this environment and so the message transmission (the design of the visual communication) is correspondingly taking place with this background knowledge in mind. This means that the transmission process being represented as a simple linear one-way process is over simplified. The issues effecting the end-to-end visual communication can be better appreciated by considering the broader operating environment. A poorly encoded message could perhaps still result in effective communication because the actors it is trying to connect have a broader understanding of what is likely to be communicated (Fiske 2011). Due to the persistent nature of visual communication in the workplace, and the time and place separation of those that have originally motivated that communication, it is quite possible that the managers in a given organisation have not in fact authored currently used signs (visual communication) and that these are inherited or imposed. However, from a proximity perspective, considering their hierarchical obligations with respect to the shop-floor (Schmidt 2005), the current managers are part of the institution and subject to the logics operating in that institution (Vardaman et al. 2012) so in this research they will be considered as custodians of the original message.

The second element in the above model is the conversion of the message to some form of signal ready for transmission. The transmitter codes the message in a way that it can be transmitted. In the case of this research, this coding is into the form of visual communication, such as the examples found on the shop-floor. Shannon & Weaver (1949) were particularly concerned with this and the associated process steps of message transmission, i.e. the technical issues of the message encoding, transmission and decoding. However in the case of visual communication in the context of this research, it is necessary to move to the extreme ends of the model and compare the information source and the destination to really understand the issues of message transmission. This is because context cannot be stripped away from the intention of the message or the recovery process (Rogoff 1990), which ultimately means that context cannot be detached from the process of visual communication as a whole. Communication as an end to end process is not just an engineering problem but is linked to its social context; it is a socially embedded problem (Rogoff 1990).

Shannon & Weaver (1949) state that communication systems have their own finite range of symbols and certain sequences (order) to these symbols that are considered an acceptable way to use them. In the example of spoken communication, there are words, and some predictable sequences to the usage of these words. Similarly it can be expected that in visual communication there are also some finite range of symbols. The taxonomy provided by Greif (1991) and Jaca et al. (2014), which is reviewed later in this chapter, alludes to such a finite list. However, in this research I have not explored the visual communication directly for its design elements and will not elaborate in detail about these issues, although some aspects are mentioned in the findings chapter.

The third element in the Shannon & Weaver (1949) model is shown as an empty box. This relates to the 'channel' and is the location where the visual communication is being displayed. This is an important aspect of visual communication because the communication is 'self-service' (Greif 1991), i.e. the operators become recipients of the message when they are able to see it. This aspect has been considered in this research through the use of appropriate methods and will be discussed in the Research Methodology and Design chapter.

The fourth element, switching to the other side of the model, is for this visual communication to be received by the operator. This is a reversal operation from that of the transmitter "...reconstructing the message from the signal" (Shannon & Weaver 1949, p4). An example of this would be the operator seeing the visual communication; the eye would be considered the receiver.

The fifth element of the model is the 'destination'. In the case of visual communication this is whoever is looking at and interpreting the visual communication from its channel, i.e. being used as a self-service tool (Greif 1991).

Perhaps due to the engineering and mathematical background of Shannon & Weaver (1949), their model is depicted as a one way process of transmitting messages (McQuail & Windahl 2015). The encoding and decoding is shown without a visible feedback mechanism to validate the meaning (Baldwin & Roberts 2006). The focus of the authors when creating this model was on the process effectiveness of message transmittal (Shannon & Weaver 1949), and faulty decoding is seen as a problem with the process, i.e. a communication failure which can be traced back to some part of the process (Fiske 2011). Although this model may seem an over simplified explanation of communication, I have considered it suitable for exploring the communication in the context of this research. Shop-floor use of visual communication separates the transmittal and receipt of the information in both time and space and is effectively a one way process. Greif (1991) refers to this separation as a "self-service" principle, arguing that the consumption of the message is autonomous.

Arguably this unidirectional communication is less a communication model but instead a depiction of information flow through some medium (Al-Fedaghi 2012). I reject the argument of it lacking a feedback loop because this seems to stem from a simplistic view of cybernetic systems, where there is an expectation to find a box within the diagram labelled 'feedback'. In fact the successive use of the Shannon & Weaver (1949) model by first one party and then a second would equally constitute a conversation, and the necessary feedback would be through repetitive use of the model rather than by some additional loop within it, for example as the one proposed by DeFleur (McQuail & Windahl 2015). I consider the Shannon & Weaver model (1949) to be elegant and representative of a visual communication system.

Many other communication models exist. Some like the Shannon & Weaver model do not have an obvious visible feedback loop, whilst other do, e.g. Osgood & Schramm 1956 Communication Model (Watson & Hill 2012). Others highlight and focus on the importance of shared fields of experience for effective communication, i.e. Schramm Communication Model 1956 and the Berlo Communication Model 1960 (Watson & Hill 2012). Issues such as sender and receiver orientations to each other and their consonance and dissonance are raised by authors such as Theodore Newcomb in his communication model from 1953 (Newcomb 1953). From the perspective of this research however none of them add anything that is not already stated or implied within the Shannon & Weaver model or add anything theoretical that has informed this study to an alternative perspective. Therefore I have used the Shannon & Weaver (1949) model to conceptually underpin this research.

In Figure 2-3 below is an adapted version of the original Shannon & Weaver (1949) process model, with headings modified to suit this research. This depicts the communication process, as it is related to the human process within an organisation, in the context of using visual communication. I will use this modified model in the next chapter to explain how the research design and methods are aligned with this conceptual model.

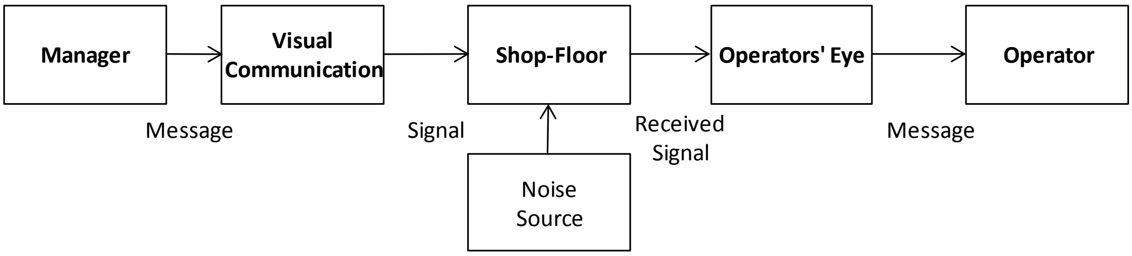


Figure 2-3 – Shannon & Weaver Model Depicting Visual Communication

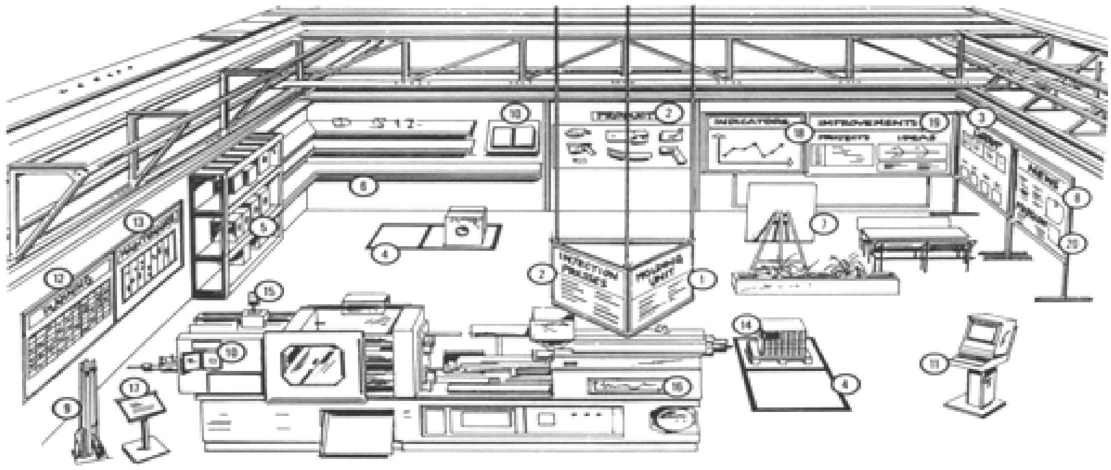
(Based on the Shannon & Weaver (1949) Communication Model)

2.4 Visual Communication Frameworks – Taxonomy

Several authors have previously identified visual communication frameworks, developed with shop-floor environments in mind. The approaches to implementing visual communication that these authors have taken have provided a useful understanding of their perspectives and assumptions. In the following section I have compared these models against each other in an attempt to synthesise an overall list of themes. This has been done to support the analysis used in the research methods as well as to provide a better understand of what is motivating the use of visual communication in shop-floor environments.

Visual communication is seen as an emergent field of study, currently without strong traditions or unifying theories (Pauwels 2006, Smith et al. 2004). This lack of a single existing holistic approach (Jaca et al. 2014) has meant that I have had to look at a number of taxonomies that were available and consider how these might inform this research.

In Figure 2-4 below, Greif (1991) identified six broad shop-floor related themes which he further broke down into twenty sub-elements. The overall motivation behind these themes is seen to be related to the control of the shop-floor which is being exercised through visual communication.



Team Territory:

1. Identification of territory
2. Identification of activities, resources, and products
3. Identification of the team
4. Markings on the floor
5. Marking if tools and racks
6. Technical area
7. Communication area and rest area
8. Information and Instructions
9. Neatness (broom)

Visual Documentation

10. Manufacturing instructions and technical procedures

Visual Production Control

11. Computer Terminal
12. Productions Schedule
13. Maintenance Schedule
14. Identification of inventories and work-in-process

Visual Quality Control

15. Monitoring signals for machines
16. Statistical process control (SPC)
17. Record of problems

Displaying Indicators

18. Objectives, results, and differences

Rendering Progress Visible

19. Improvement activities
20. Company project and mission statement

Figure 2-4 - A Visual Workplace

(Greif 1991, p20-21)

Greif (1991) describes visual communication as acting as a self-service compass. The point he is making is that visual communication is reinforcing control through orientating organisational members. He reiterates this point by speaking about how visual communication supplements, but does not replace, the normal hierarchy. He also states, in a sense repeating the same message, that "visual communication challenges the mode of expression adopted by hierarchical authority rather than the form of authority" (Greif 1991, p19). The issue of management control as a motivation for using visual communication is a theme that runs through this research.

In contrast, the potential to tailor and distribute visual communication to specific audiences within the organisation has been argued by some authors to be for the purpose of empowerment. Kattman et al. (2012) and Galsworth (2004) have argued that the purpose of visual communication is not about perpetuating the "command-and-control tradition..." (Galsworth 2004, p46) but instead to drive empowerment by providing answers to operators that allow them to be more autonomous. I partly agree that visual communication serves the purpose of autonomy. However, this autonomy is constrained by bureaucratic controls which define the roles and responsibilities of individuals within the organisation. An example of this is the Tayloristic standard operating procedures based on time and motion study principles which define the work expected of those on the shop-floor to within second increments (Towill 2010).

My view of the autonomy offered through the interaction with visual communication is that it is pseudo autonomy and that a relatively mechanistic (compliant) behaviour is expected. Any empowerment is about how control is distributed closer to the point of action, i.e. some decision making is moved closer, in time and space, to where it can be made, but the range of decision making is not open, but often limited to binary choices. When there are any areas of uncertainty then the respective group, for example the operators, are instructed to escalate the issues to the next level of the hierarchy (Hoseus & Liker 2008), and the process of escalation itself is clearly defined and insisted upon.

It is to be remembered that visual communication is not a stand-alone communication but is set in an overall context of control within the organisation. As such the autonomy is limited by the heavily regulated environment of a mass production shop-floor. Galsworth (2004, p44) acknowledges the role of a visual workplace in providing a regulated and controlled environment in the comments "...a visual workplace is a self-ordering, self-explaining, self-regulating, and self-improving work environment where what is supposed to happen, happens on time, every time, because of visual devices". The use of the word ‘supposed’ is in recognition that there is a predetermination to what is considered legitimate. In accepting that the visual communication has been placed there by the management, the self servicing of that communication by the operators does not seem to really be empowering them. In the discussions to follow, identifying the needs of a mass production environment, I think further highlights that visual communication is not being used for the purpose of empowerment.

In Figure 2-5 below is shown a comparison of the Galsworth (2004) visual communication elements (left) alongside the Greif (1991) elements and sub-elements (right). Connector lines have been added to indicate where I considered these themes are similar.

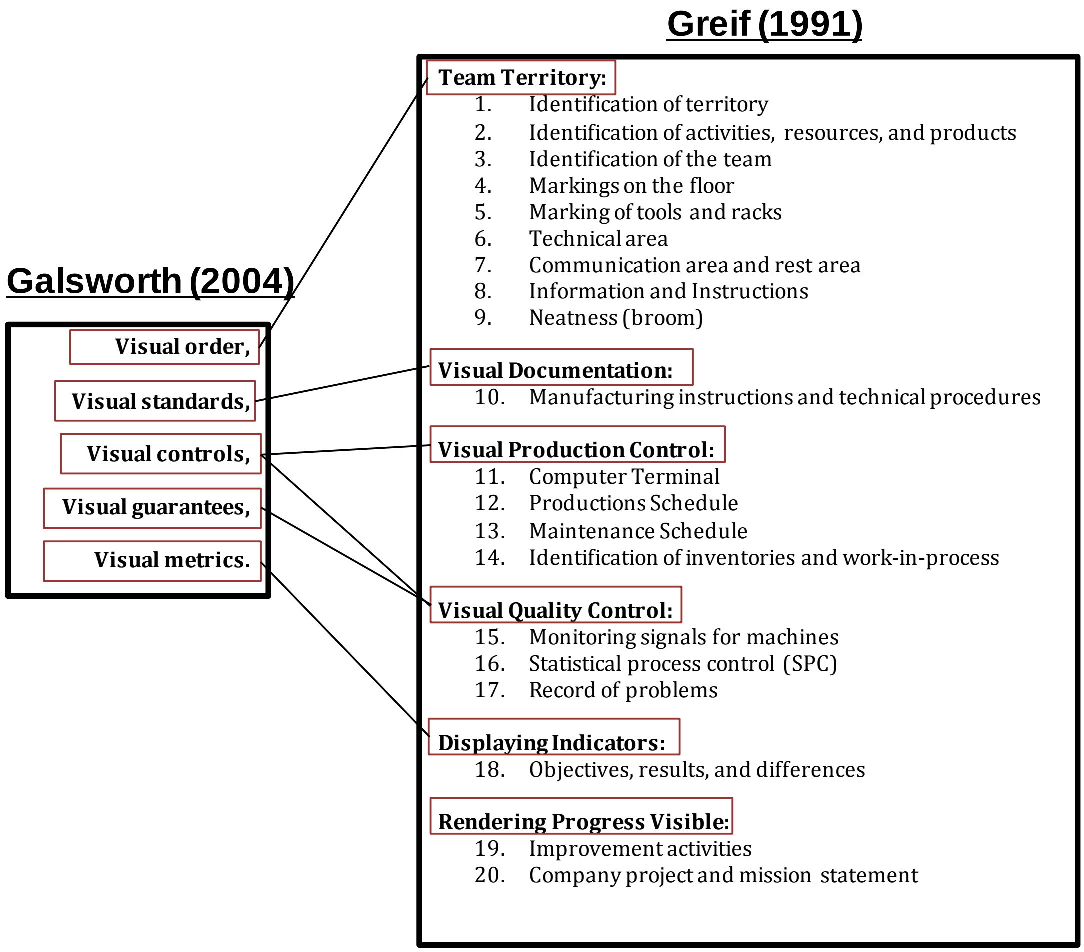


Figure 2-5 - Comparison of Galsworth (2004) v Greif (1991) Frameworks

(Diagram by author)

This comparison indicates a significant overlap between the two characterisations, although there does seem to be one key gap. The "rendering progress visible" is an element within the Greif (1991) definition but seems to be absent from the Galsworth (2004) list. From Greif's (1991) description this element is geared to the orientation of operators towards the organisation, so has an underlying cultural control theme to it. This is explained by his comments "...visual communication cannot flourish without certain attitudes. At the same time however it contributes to the development of those attitudes" (Greif 1991, p266). Galsworth (2004) on the other hand does refer to empowerment opportunities through the use of visual communication but overall retains a more modernist view of the organisation.

A further useful visual communication framework is proposed by Mestre et al. (2000). This framework identifies the function and purpose of visual communication as "...a tool to focus individuals around joint purposes" (Mestre et al. 2000, p34). In Figure 2-6 below, the elements presented by Mestre et al. (2000) (on the left) are arranged along with those identified by Greif (1991) (on the right). The overlap here is arguably more focused around the cultural aspects of the organisation which highlights that the focus by Mestre et al. (2000) was more aligned with a neo-modernist perspective of the organisation. However, the view is still firmly entrenched within a "hierarchical organisational structure" (Mestre et al. 2000, p34) and is not advocating any form of democratisation of the shop-floor.

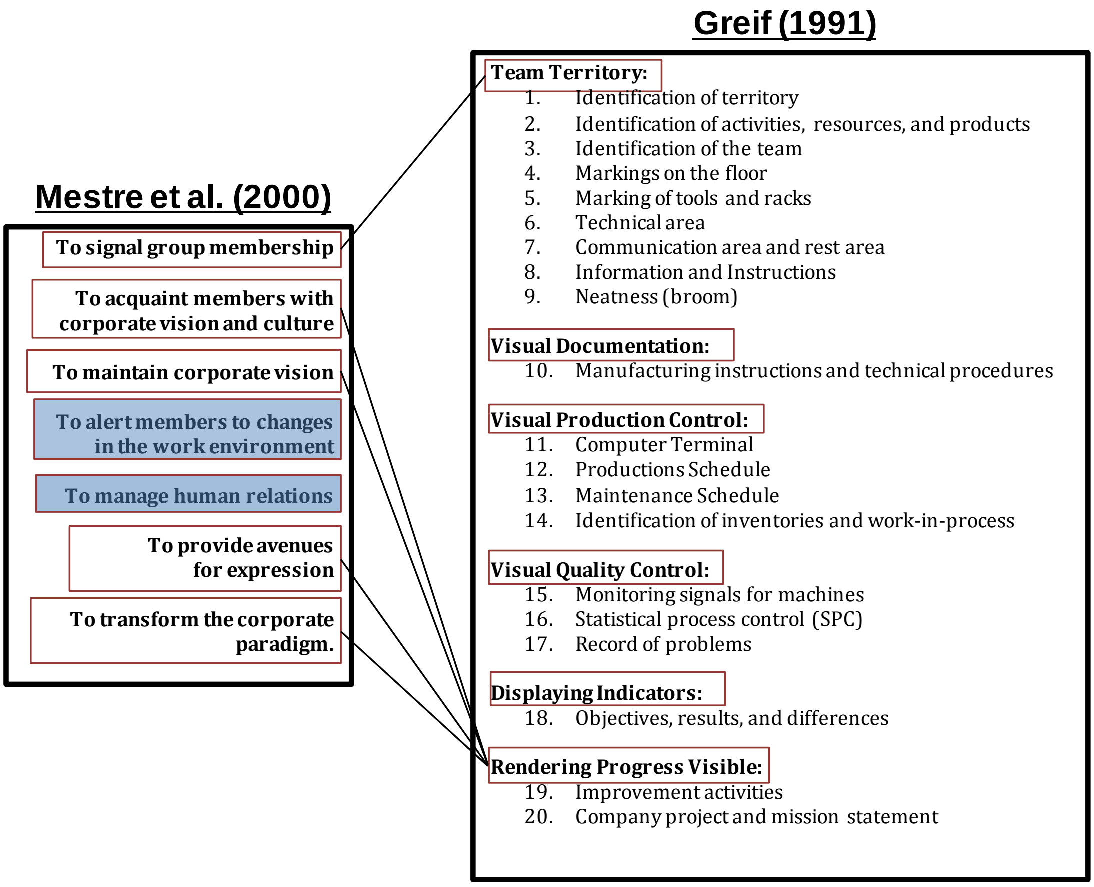


Figure 2-6 Comparison of Greif (1991) v Mestre et al. (2000) Frameworks

(Diagram by author)

I have highlighted, in the shaded boxes above, two elements in the Mestre et al. (2000) model that do not readily align with the Greif (1991) model. The first of these is 'to alert members to changes in the work environment' (Mestre et al. 2000, p39). This is about the use of visual communication to convey to employees any new or changed procedures. The second is 'to manage human relations' (Mestre et al. 2000, p39). This relates to the use of visual communication to provide an arena for a non-confrontational approach for communication. These two elements do not contradict any of the elements within the Greif (1991) framework and could in fact be used to extend that model more deeply into the cultural control aspects of visual communication. This is further elaborated by Mestre et al. (2000) who mentioned the following four types of specific visual communication, i.e. workplace artefacts, personal artefacts, proxemic cues and personal / corporate rituals. The use of the words artefacts, cues and rituals is consistent with the description that Schein (2010) provided to identify culture within an organisation. Schein (2010) stated that at a surface level, artefacts point to the underlying culture:

> "Artefacts include the visible products of the group, such as the architecture of its physical environment; its language; its technology and products; its artistic creations; its style, as embodied in clothing, manner of address, and emotional displays; its myths and stories told about the organisation; it’s published lists of values; and it's observable rituals and ceremonies...".

(Schein 2010, p23)

The highlighting of the use of visual communication to affect these cultural markers is consistent with the comments by Greif (1991) who argues that visual communication implementation is both reliant on, but also affecting of, the attitudes in the organisation.

The framework shown in Figure 2-7 below, proposed by Jaca et al. (2014), is a synthesis of the above visual communication frameworks. It has combined the frameworks provided by Greif (1991), Mestre et al. (2000) and Galsworth (2004) and related them to fostering continuous improvement (CI) in the organisation.

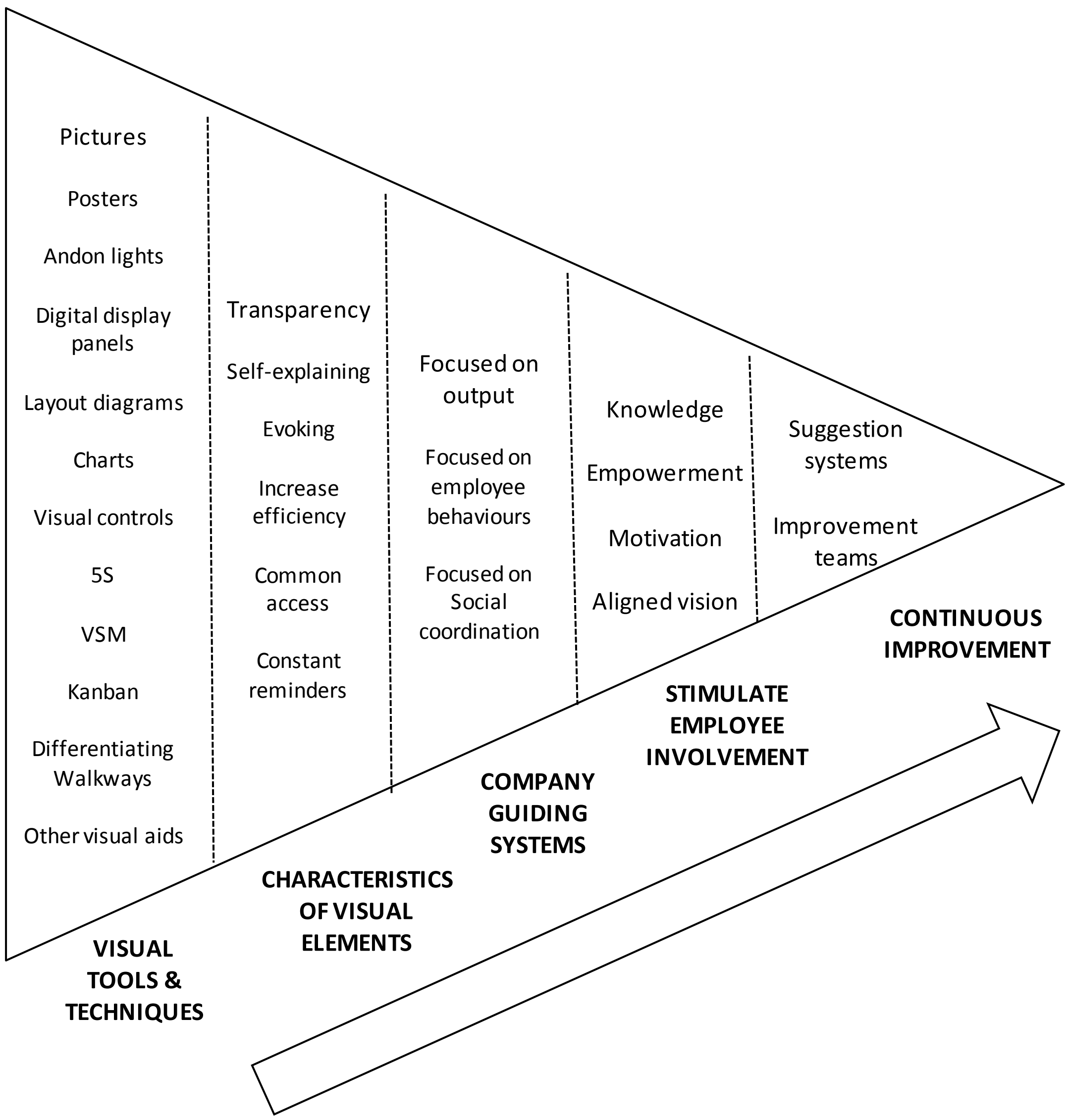


Figure 2-7 - Synthesis of Visual Management Frameworks

(Jaca et al. 2014, p1758)

The interesting aspects of this framework, relevant to this research, are the elements within the "company guiding systems". The individual frameworks mentioned earlier state or imply the use of visual communication for control. However, Jaca et al. (2014) are much more explicit in linking back to the types of control referred to by McAuley et al. (2014), i.e. 'focused on output' = output control, 'focussed on employee behaviours' = cultural control and 'focussed on social coordination' = bureaucratic control. This further asserts the broad usefulness, or even necessity, of visual communication in supporting managers in their exercising of control within organisations. I mention here, as a reminder to the reader, that the above comparison of frameworks is not intended to create a new framework but only to identify themes that can be used as comparators for those that emerge from this research.

From the visual communication frameworks explored above there were some themes that did not seem to be adequately covered. These potentially missing themes stem from a contingency based organisational perspective. The idea of contingency is effectively to argue that aspects of the organisation, for example its overall design (McAuley et al. 2014, Lawrence & Lorsch 1967), are dependent on contextual factors, as opposed to being solely based on general principles. Contextual variables that might be considered as contingent are external environment, technology, organisational structure, size and strategy (Wang & Wang 2016, Chenhall 2003). Interestingly however, these do not seem to be included in the current existing visual communication frameworks presented above.

Overall the current visual communication frameworks seem generic and not sufficiently developed enough to cater for the vertical (departmental) and horizontal (hierarchical) differentiation of organisations. For example it is unclear how they are supposed to support the communication needs between and across the differentiated elements of the organisation, i.e. different production areas (value streams) or departments. Existing visual communication frameworks assert that they are applicable to the shop-floor environment but they do not account for the hierarchy that operates there and the differing needs in terms of information (Jaques 1990) of those at different hierarchical levels. Recognising that visual communication is being used as part of the performance management system (discussed later in this chapter), which covers the strategic, management and operational levels of the organisation, also requires that the visual communication frameworks should recognise this dynamic.

In addition, complexities such as de-layering, where managers can be tasked with responsibility for all three of these performance management areas (Otley 1999), only adds to the need to consider the specific nature of the shop-floor in modern manufacturing environments and their corresponding needs from a visual communication perspective.

An interesting insight into the nature of hierarchies was proposed by Jaques (1990). He argued that one way to conceptualise the levels of the hierarchy was to observe the differences in respective levels in relation to the time frames. These time frames are the longest target completion time for any task assigned to that job function. These time-based discontinuities he argued serve to help visualise a "universal truth" (Jaques 1990, p130) about the structure of hierarchies. In fact what Jaques (1990) was arguing is similar to the argument by Lawrence & Lorsch (1967) about the time orientations of organisational members as being related to the time it takes them to get feedback from their respective sub-environment. In the context of visual communication, this assertion by Jaques (1990) could be usefully superimposed on to existing visual communication models to reflect the differing needs from visual communication in line with the respective time horizons associated with each of the hierarchical levels.

In relation to the contingency of strategy, the discontinuities in the hierarchy and how this informs the way in which visual communication might be considered are echoed by the issues raised by Lee & Dale (1998). They described the discontinuities that are necessarily there when implementing strategy deployment. This is the cascading of objectives to each level of the hierarchy consistent with the overall vision of the organisation.

Lee & Dale (1998) described an issue that they referred to as “abstract versus concreteness". This is related to what can be thought of as abstract high level strategic policies and how they need to be made progressively more concrete as they are cascaded through the organisational hierarchy. Visual communication as an instrument affecting control can be expected to reflect this increasing objectification of strategy as it is cascaded. This would practically mean that the visual communication at the shop-floor level would remain consistent with the high level strategy but would speak to the operators in a way that is meaningful to them. The risks of getting this cascading process wrong were identified by Kogure (quoted by Lee & Dale 1998) as:

- "Management policies of superiors and subordinates are both abstract and deployment of policy is carried out only perfunctorily.
- Content of superior manager's policy is too concrete.

- A gap between the superior manager's policy and the subordinate’s policy is conspicuous because the former is too abstract and the latter is to concrete".

(Lee & Dale 1998, quoting Kogure)

The risk of getting the deployment process wrong is that the thrust of the overall vision is lost as is it progressively cascaded. However, even if it is efficiently cascaded, there is still the risk that badly encoded visual communication could still dilute the message. This issue highlights one of the important contributions that this research makes in enabling the effectiveness of visual communication to be checked at the shop-floor, and enabling the reconnecting of strategy and objectives.

The remaining significant contingency factor that seems relevant to visual communication, but seems to be given little prominence by existing research, is the national culture within which the organisation is situated. Edward T Hall's concept of high/low context communication asserts that individuals have a pre-programmed cultural specific context (Kittler et al. 2011) that directly influences the way in which communication is affecting. Hall proposed three interrelated dimensions of culture as being important to communication. The first of these was "time”. This referred to how members of different cultures orient towards time and the way they perceived it (monochronic vs. polychronic). The second was “space”. This referred to differing cultural frameworks for defining and organising space. The third was “context”. This was the nature of how meaning has been constructed differently across cultures using different context and information (Kittler et al. 2011, p65 referring to Hall).

Within a shop-floor context, accepting that it is in a relatively closed environment (Thompson 2004), it may be that that by standardisation and training, the differences in the use of communication by different cultures can be normalised. However, in recognising that visual communication is often deployed as a corporate requirement and may be deployed in a cut-and-paste mode in different geographic regions, it is realistic to think that cultural contingency may be an issue and should be considered. Within this single case study research this factor was difficult to realise and assess. It was however an additional dimension that was noted and would form part of any wider visual communication framework related to shop-floor deployment.

Based on the above review of literature and discussion I have added the potential missing themes to the framework by Jaca et al. (2014), see Figure 2-8 below.

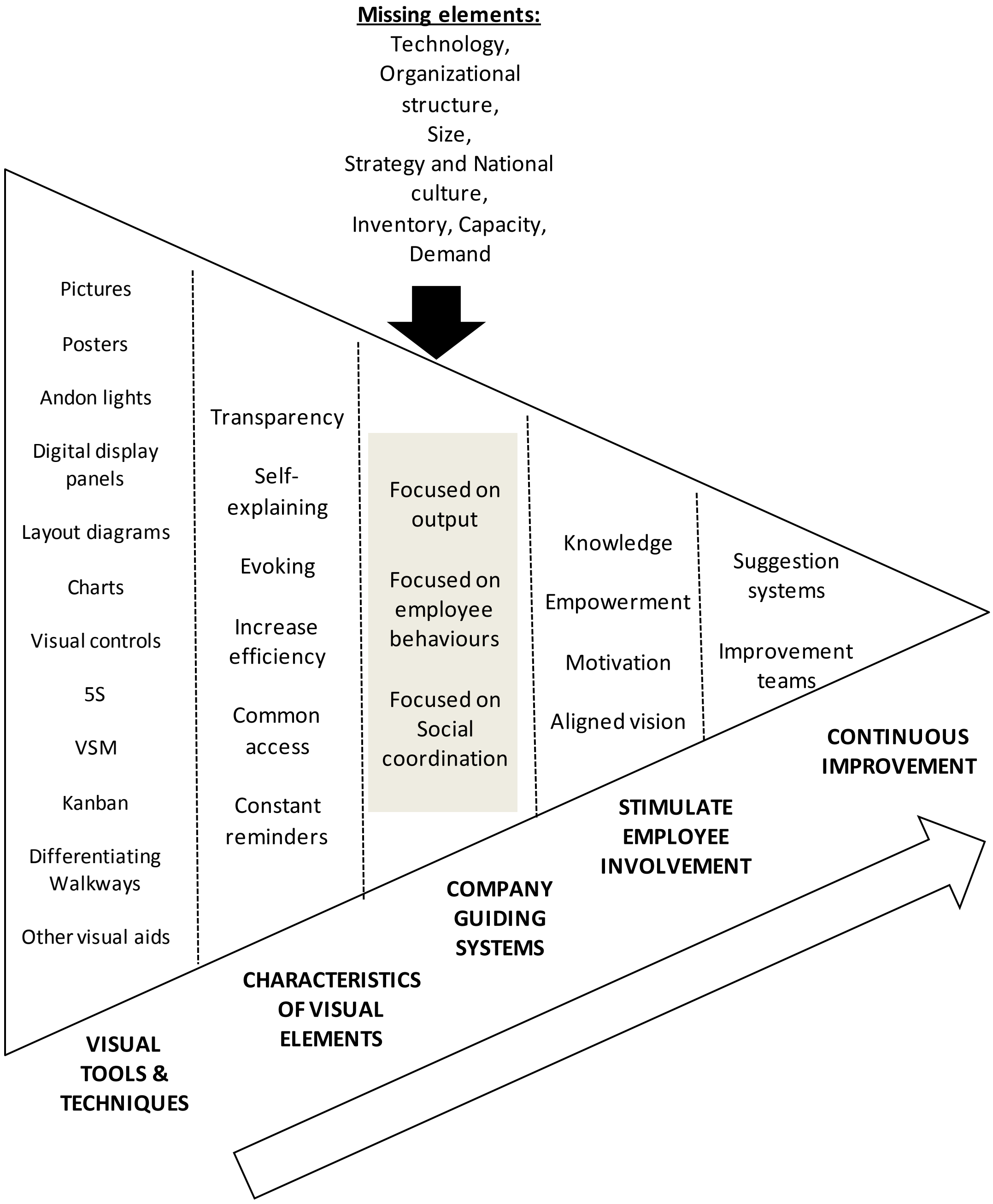


Figure 2-8 - Synthesis of Literature and Jaca et al. 2014

(Diagram by author, based on model by Jaca et al. 2014, p1758 and additional categories identified from the literature review)

What I have added to this diagram are the themes and contingencies that have emerged from the above discussion. The first is ‘technology’, based on the generic types of organisations have been identified and characterised by Thompson (2004); based on the core technology they utilise. This should be included in any synthesis as it arguably drives the subsequent imperatives and therefore the key issues that are in need of being communicated. Next are the contingencies identified by Wang & Wang (2016), i.e. strategy, structure, size and national culture. Finally are the shop-floor contingencies identified by the operations management triangle proposed by Schmidt (2005). These are said to be the shop-floor related imperatives that are constantly being managed and balanced, i.e. the substitutability between inventory, customer demand, and available capacity. I have aligned these directly above the ‘company guiding systems’ section of the triangle to indicate that they potentially impact the way in which the organisation is controlled. The issue of control in organisations will be further developed later in this chapter.

In summary, in this section I have compared various visual communication models in an attempt to synthesise an overall list of themes. As a potential taxonomy and guide to this research it was necessary to superimpose the specific context of the shop-floor environment and the imperatives that operate there. This provides guidance to the nature of the visual communication in organisations and supports the analysis used in the research methods by theorising about what can be expected to be revealed in terms of themes.

The comparison of several visual communication models indicated significant overlap in themes, although some gaps were also identified. These missing elements from the models potentially highlighted how the visual communication, in the context of control, might be contingent on additional factors such as technology or organisational structure, but it did not suggest that visual communication was for any purpose other than for control.

The remainder of this review is focussed on introducing a theoretical perceptive of organisations that I will argue is relevant to this research and its particular context. This perspective will be used to explore the role of visual communication and how it critically supports organisational performance.

2.5 Theoretical Perspective of Organisations

To help contextualize this research it is useful to identify the specific perspective of organisation that has been taken. Organisations appear in a variety of different shapes, sizes and purposes. They range from a handful of individuals to huge nationals and multi-nationals, employing tens of thousands of people (Scott 1992). There are many ways of considering organisations from a categorisation point of view. Examples are public, private and voluntary sectors. However, it is necessary here to find a way of describing them that is useful from the perspective of this research. This point is made by Rich (1992, p760) who states that "in the final analysis, classification systems are judged not by the ease or neatness through which the organisations are grouped but by their utility and the ability to replicate reality".

General System Theory is "a way of thinking about or an approach to studying, complex systems" (Hammond 2010, p104). This perspective is intended to make it easier to study complex systems by breaking them down into sub-systems and describing them individually as well as their relationship with other systems. "They are 'systems' because they are made up of a number of different parts (the sub-systems) that depend on each other, and are related to each other, sometimes in very simple ways and sometimes in complex ways" (McAuley et al. 2014, p69).

It is first relevant to explain the difference between closed and open systems. A closed system is said to exist if there is no exchange of materials with the environment, i.e. nothing enters or leave the system (Bertalanffy 1950), whereas an open system is where there is an exchange of materials with the environment (Scott 1992). From a factual point of view, organisations do not exist as closed systems. However, some parts of organisations can be 'relatively' closed (McAuley et al. 2014) and arguably need to be relatively closed to affect profitable stability (Thompson 2004). This last statement is important because the view of organisations that I have presented below is consistent with the theory where it is argued that for certain types of organisations, or parts of the organisation, there is a technical rationality in effective closure of the shop-floor from the environment (Thompson 2004).

In thinking of organisations as comprising systems, it is the relationship and interdependence between these sub-systems that helps to identify the differences amongst them (Scott 1992). Boulding (1956) describes nine different levels of complexity ranging from the most simplistic static structures to deeply complex systems that he refers to as transcendental systems. For this research, those specified by Boulding (1956) at level three are the most relevant. These are referred to as 'Control mechanisms' or 'Cybernetic systems' (Boulding 1956). Classically these are described as representing a thermostatic system (Scott 1992), i.e. where the system, through differentiated sub-system elements, is capable of regulation by comparing actual and desired temperature.

Shown below in Figure 2-9 is the representation of an organisation as a cybernetic system (Scott 1992). It can be seen to be made from a number of sub-elements, materials and information flows; the flows represented by the numbered arrows. The policy center is where the overall goals for the system are set. This is in response to the requirements as they are interpreted from the environment. These are transmitted to the control center in the form of goals, policies or standards. The control center has two roles. One is to transmit programs to the operation center in relation to what they are to manufacture. The other is to monitor the outputs of this operations center and regulate it to ensure that it operates in accordance with the policy center, i.e. ensuring that the safety, quality, cost and delivery of products is according to those targets set by the policy center. The regulation is affected by actions taken to correct discrepancies (Scott 1992) between target and actual. The diagram also shows a second feedback loop returning to the top of the diagram, connecting to the policy center. This is to monitor the overall performance of the system to ensure that it is aligned with the on-going needs of the environment (Scott 1992).

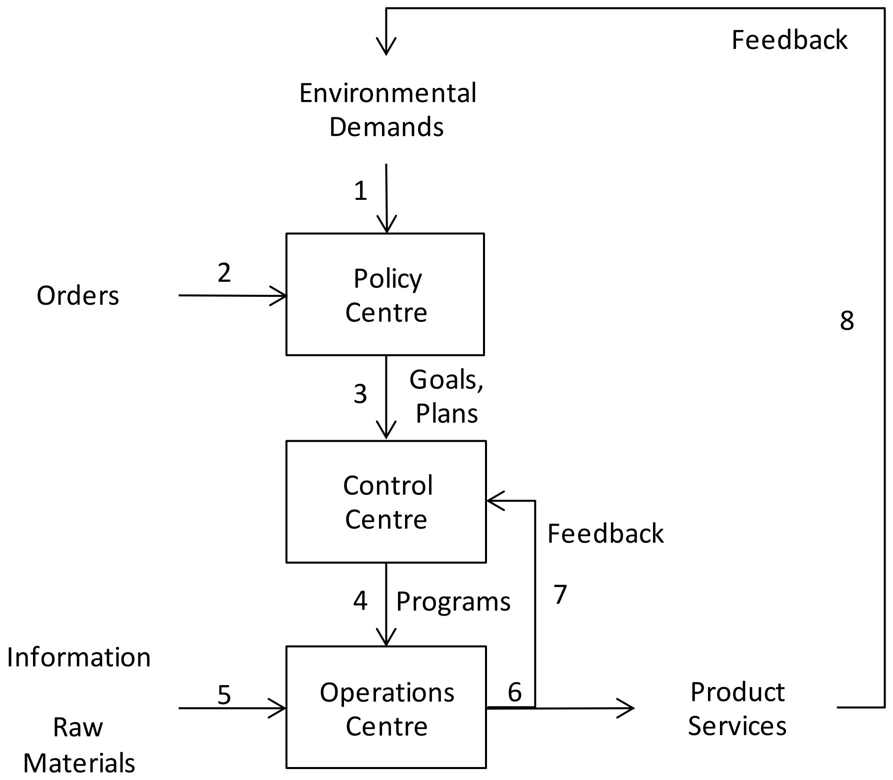


Figure 2-9 - Abstract Model of Cybernetic System

(Scott 1992, p81, adapted from model by Swinth)

The organisation as a whole is shown as an 'open' system because there is an exchange between the organisation and the environment. At the same time the operations centre (bottom box) is relatively closed in having standardised inputs, outputs and expectations in its behaviour (Schmidt 2005, Thompson 2004).

The role of visual communication in this overall scheme is that it is a component part of this cybernetic system. It is part of the information flows that are designed to ensure that people in the organisation are clear about their objectives (Liker 2003, Lee & Dale 1998). It is also an important component for visualising the current status in respect of those objectives (Liker 2003). It is used for communicating targets, goals, policies and procedures (Bateman et al. 2016, Lee & Dale 1998) as well as monitoring and controlling them. This is a theme that I will develop later in this chapter.

The shop-floor is represented by the 'operations centre' in the above figure. In this research the aim was to focus on visual communication that is associated with this part of the overall organisation. I have partially redrawn this diagram to depict the scope of this research, see Figure 2-10 below. This diagram also helps to explain the importance of this research, as the effectiveness of the intended and interpreted meaning of visual communication used in this context is correlated to how well the organisation is able to regulate and function.

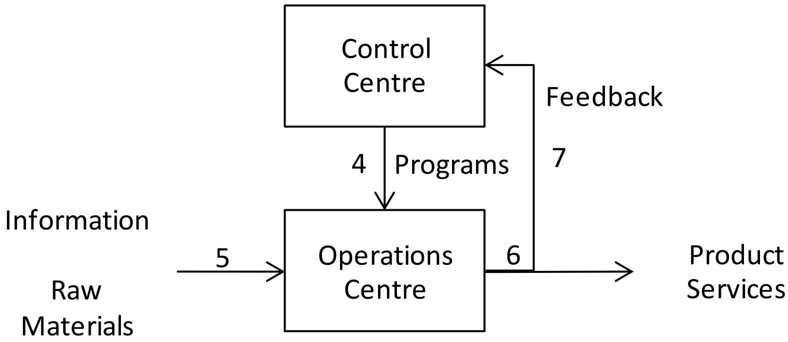


Figure 2-10 - Abstract (Truncated) Model of Cybernetic System

(Truncated by Author - Scott 1992, p81, adapted from model by Swinth)

Having presented a theoretical view of organisations as systems, and highlighting the specific role that visual communication plays, it is necessary to redress the absence of people in the above diagram by introducing socio-technical systems theory.

As discussed earlier socio-technical system theory focuses on the relationship between the interrelated and interdependent variables of "...people, technology, and environment…" (Cummings 1978, p625). Organisations are designed to perform some primary tasks. In the case of Automotive UK, it is to produce particular specification products, at a specific rate, for a number of customers. Focusing solely on these imperatives, and designing the organisation based on these primary task needs, without regard for the needs of those working in this technical core of the organisation can result in an overall loss. For example studies conducted in the coal mining industry (Trist & Bamforth 1951) showed that by ignoring the human element of the organisation, people became frustrated to the extent that the performance of the task was subverted. Socio-technical systems thinking asserts that it is necessary to understand the needs of the primary tasks that the organisation has been set to perform along with the socio-psychological needs of individuals and groups performing those tasks (Miller & Rice 1967). Compromising the task needs with the human needs of those who are performing them aims to foster improved productivity and human enrichment. This view builds on the purely modernist view of the organisation as a cybernetic system shown in Figure 2-10 above. It does this by recognition that the system also comprises people and their needs must be attended to. In this thesis I have continued below to use the cybernetic system model, however it is not in ignorance of the socio-technical view and in fact the very subject of this research is to better understand the interface between one form of technology, i.e. visual communication, and people.

Having considered organisations as systems (open and closed), and introduced the ideas of cybernetics and socio-technical theory, next I have explored how organisations can be further characterised. This is relevant as it helps to explore the nature of visual communication messages, i.e. what is it specifically that is being communicated.

2.6 <u>Organisational Characterisation</u>

In this next section I have explored the key imperatives for typical mass production environments. This helps to explain the uses that visual communication is put to as part of the shop-floor cybernetic control system. By exploring characteristics, such as shop-floor layout, also helps to highlight how the shop-floor cannot be considered to be a single system, but is further differentiated into sub-systems that focus on particular products and/or customers. This helps to characterise the visual communication imperatives as well as explaining issues that are important for the research design and methods.

Mass production can be used to define an organisational type; also referred to as long-linked technologies (Scott 1992). It is the design and use of specific technology to produce large volumes of products of a single (or limited) type at a relatively constant rate. The repetitive nature of production in these organisations means that knowledge about the best way to select and organize the resources of the organisation can be perfected over time (Scott 1992). The utilisation of resources to meet the organisational goals is measured in respect of efficiency and effectiveness; the efficient use of organisational resources to effectively meet the needs of its customers and other prioritised stakeholder groups (Dumond 1994). I will argue that these organisational resources and their necessary tuning and blending highlight the central themes around which visual communication is focused.

In mass production organisations it is predicted that there are attempts made to affect closure of the shop-floor from external environmental disturbances (Thompson 2004). Such organisations are considered relatively technically rational. "Under norms of rationality they seek to buffer environmental influences by surrounding their technical cores with input and output components" and these types of organisations "…seek to smooth-out input and output transactions" (Thompson 2004, p20-21). This is described as "buffering" and takes two forms. One is input buffering which is the stockpiling of materials and supplies to smoothly feed the production process. The second is output buffering which is the use of inventory to ensure an undisrupted supply of products to the customer. Thompson (2004) also identified the need for 'smoothing' or 'levelling' the peaks and troughs of customer demand for product in an attempt to absorb fluctuations and avoid these perturbing the smooth running of the shop-floor.

Implicit in this is that a factory organised around mass production principles must generally produce en-masse to be efficient (Thompson 2004), and these are the reasons for the above actions; to ensure the smooth running of the production lines. The attempt to close off the shop-floor from external disturbances is to satisfy the 'needs' of the organisation to work smoothly. It is these needs (Schmidt 2005) that are in part transmitted and affected using visual communication.

Some of the key focal areas for shop-floor visual communication are described by the 'operations management triangle' (Schmidt 2005). This describes three imperatives that are central to the trade-off decisions that have to be made by mass-production organisations in terms of their operations (Schmidt 2005). The operations management triangle asserts that there is a need to constantly seek balance of the substitutability between inventory, demand information and available capacity when balancing production. Schmidt (2005, p93) stated that "...a higher level of capacity can substitute for relatively lower levels of inventory and information, a higher level of inventory can substitute for relatively lower levels of capacity and information, and a higher level of information can substitute for relatively lower levels of capacity and inventory". These imperatives and their need for dynamic substitution are areas where visual communication can be expected to be used for control and communication within mass production shop-floors.

Perrow (1967) proposed to treat the technology of the organisation, i.e. mass production, as an independent variable which determined both the structure of individual departments and the overall structure of the organisation. Within organisations that can be characterised as being designed for mass-production, epitomised by long-linked technology organisations, the production equipment and specifically how it is physically organised must be considered. Physical layout influences the relationship between people (Liker 2003) and therefore what is communicated through visual communication. Figure 2-11 below shows two forms of organisational layout.

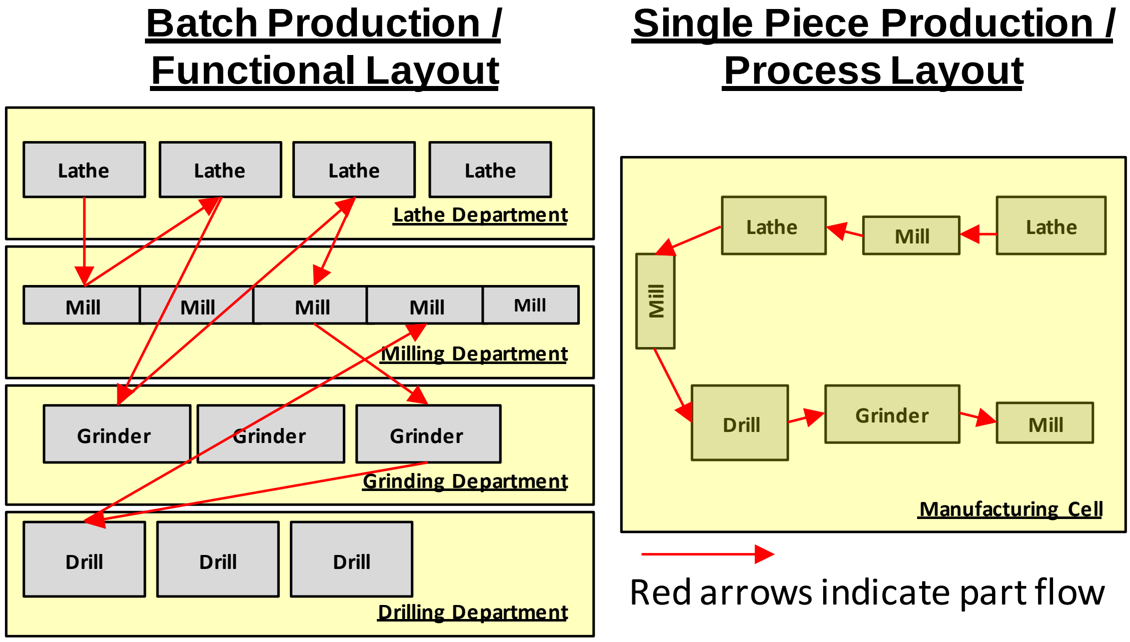


Figure 2-11 – Functional Layout / Process Layout

(Based on the diagram by Liker 2003, p97)

The diagram on the left depicts a layout characterised by groups of similar machines and therefore similar skills requirements (Liker 2003). In this layout the product is necessarily produced in batches and is transported from machine group to machine group, which could be different departments within the same organisation (Rother et al. 2003). The diagram on the right shows a different way of organising the shop-floor. Here the necessary processes have been arranged for a product requiring a particular sequence of manufacturing operations, also known as ‘value streams’ (Liker 2003). The layout enables the product to flow from one process to the next; the idea of single-piece continuous flow production cell (Liker 2003). In a given organisation there might be a number of such value streams, suited to different products and/or customers.

These different layout choices are relevant to this research because they influence the nature of the visual communication; they change the relationship between people. Both layouts enable the use of work groups, defined as a group of employees in the same unit who do the same or similar work and have to coordinate their work activities (Galbraith et al. 2002). However work-groups and team-work are not the same. The layout on the right, because of the flow design, promotes team-work (Liker 2003). This is relevant to this research because team-work is defined as "everyone working towards the same aims and objectives" (Wickens & Marsh 1987, p95). In this single-piece flow (value stream) layout there is a mutual benefit in cooperation in that only if the product moves through respective workstations is the next product produced. This is absent in the piece-work mentality of the functional layout (left diagram - Figure 2-11 above).

In the single-piece continuous flow layout, the general lack of in-process-inventory means that problems inhibiting the smooth flow of work quickly becomes apparent to the whole group. As such the expectation would be for the visual communication to relate to the performance of the whole cell as opposed to just individuals processes. It is also relevant to mention that different value streams could have different targets depending on their specific customers, manufacturing technology, and the way that technology is being utilised.

Some authors have suggested that viewing organisational variables such as structure as being dependant on, for example, the transformation process (Perrow 1967) is to ignore the political aspects of “strategic choice” that “power-holders” exercise over the organisation. This power is said to be exercised in both making choices in relation to the organisational structures that are adopted but also in manipulation of the environment within which the organisation operates (Child 1972). Despite partly agreeing with the view that the organisational leaders have choices about structure and that these choices are a blend of logic and politics, these choices are limited by environmental contingency. This is highlighted by Lawrence & Lorsch (1967). Their work identified that organisational structures and the economic performance of the organisation are correlated. Arguably from an ecological perspective (Scott 1992) the wrong structure is not long term demonstrably viable (Dominici & Palumbo 2013).

In the above section I have identified some of the imperatives that define the uses of visual communication. Visual communication as part of the cybernetic (shop-floor) control system can be expected to support the management of materials (raw materials and finished goods) as well as customer orders (Thompson 2004). This is consistent with Schmidt (2005) who argued for the need to regulate capacity, demand and materials, as interdependent imperatives. Additionally the layout of the factory could mean that the emphasis on these imperatives is different for different value streams, recognising that different production cells (value streams) are designed to satisfy different products and/or customers, so that they could have different performance targets defined.

2.7 Visual Communication as a Form of Control

Having explored what is being communicated, through the taxonomy review and organisational characterisation, in this section I have looked at why visual communication is being used. I have explored the need for control and how visual communication is relevant to affecting this.

There is said to be a need for managers to inform and engage employees to "act intelligently in the interest of the entire enterprise" (Bititci et al. 2016, p1). Part of this need is fulfilled through the use of visual communication. Based on the premise that visual communication on the shop-floor is motivated by the need for affecting control, in this section I have explored different formal types of control within organisations and explained how these are related to this research.

McAuley et al. (2014), drawing on the ideas of Perrow and Ouchi, identified that the transformation processes and task outputs strongly influence the generic type of controls that should be considered, i.e. that they are contingent. Figure 2-12 below shows different types of transformation processes and task outputs in the form of a matrix. The transformation process is shown to range from routine, analyzable and predictable to an environment where there are many exceptions and a higher level of unpredictability. The nature of the task outputs are also shown to range along a continuum, from stable and measurable to relatively unstable.

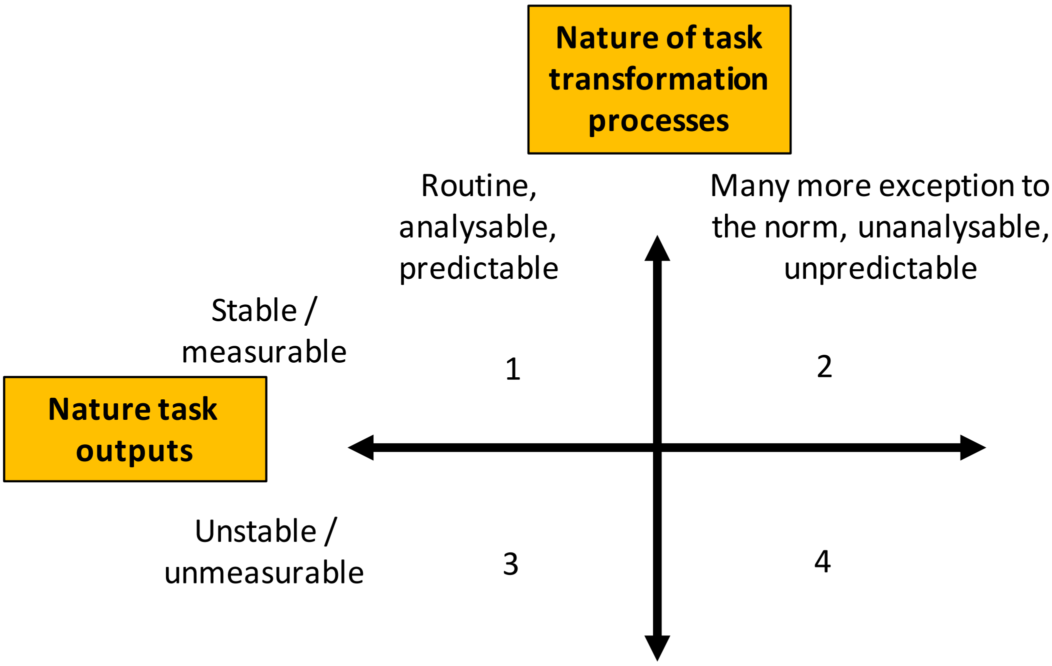


Figure 2-12 – Factors Impacting the Viability of Different Forms of Control

(McAuley et al. 2014, p166)

McAuley et al. (2014) identified the three different types of formal control arrangements as bureaucratic, output and cultural. Bureaucratic controls relate to policies and procedures that specify how tasks should be completed. Output control is where feedback is provided to those that are being controlled such that this feedback itself elicits appropriate behaviours. Cultural control is the control of operators through identifying and aligning their values to those considered appropriate by the organisation.

A mass production shop-floor, such as the one in the case study site, can be said to be located within segment one of the above matrix. McAuley et al. (2014) stated that within this segment the types of controls that can be expected to be operating are bureaucratic and output controls. However, as will be discussed in the next section of this chapter, organisations can be differentiated both vertically (Lawrence & Lorsch 1967) into product focused production areas (value streams) and horizontally (Schmidt 2005), when we consider the hierarchal structure. Therefore it is possible that in a mass production environment, even on the shop-floor, there are in operation all three different forms of control. Visual communication that operates within such environments may be expected to contribute to affecting control in one or many of the above mentioned ways. In addition there are also likely to be contradictions between formal and informal aspects of the organisation depending on the relative success in crafting the hierarchy (Jaques 1990), and the way in which the differentiated parts of the organisation are integrated together (Lawrence & Lorsch 1967). Part of the cause of these contradictions is the ongoing environmental influences that necessitate contingent change within the organisation.

As outlined in the introduction, this research has been focused on the shop-floor. In this respect the issues of control are covered by the umbrella term of operational control rather than strategic planning or management control (Otley 1999). However, this is not to say that individual managers, including those close to the shop-floor are not sometimes responsible for strategic and management control issues. This would be consistent with the notion of de-layering (Baumol et al. 2003). Otley (1999) stated that "...the same manager may well be responsible for some elements of strategy, management control and operational control" (Otley 1999, p365). This point highlights that the shop-floor use of visual communication could correspondingly include strategic and/or management control and may not be restricted to only operational control. In a relatively flat organisation these differentiated uses of visual communication might not be clearly discriminated in the minds of those tasked to affect that communication.

Considering these debates and using them to inform my overall research design and methods, I have recognised that the controls being deployed on the shop-floor may be a witting and unwitting blend of all three different types. The cutting and pasting of visual communication from what has worked elsewhere without due consideration to the specific needs of the hierarchical and lateral integrative needs of a given organisational context (Galbraith et al. 2002) may mean that the motivation behind the use of visual communication is less than clear.

2.8 Performance Management Systems

From a management perspective, the use of visual communication at the shop-floor level is more than just displaying metrics related to the mass production imperatives identified earlier. To affect control of these imperatives it is important that the visual communication is used to communicate the goals of the organisation to the operators in a meaningful way, and too stimulate in them the desired behaviour in support of those goals (Fullerton et al. 2014, Leeuw & Berg 2011). In the diagram below I have shown again the cybernetic systems model indicating the area of focus for this research (see Figure 2-13 below). The information flows indicated by the input and output arrows to the operations centre indicate respectively the goals of the organisation being cascaded and the feedback necessary to know if the organisation is meeting these goals. This is the area of focus for this section and the discussion below.

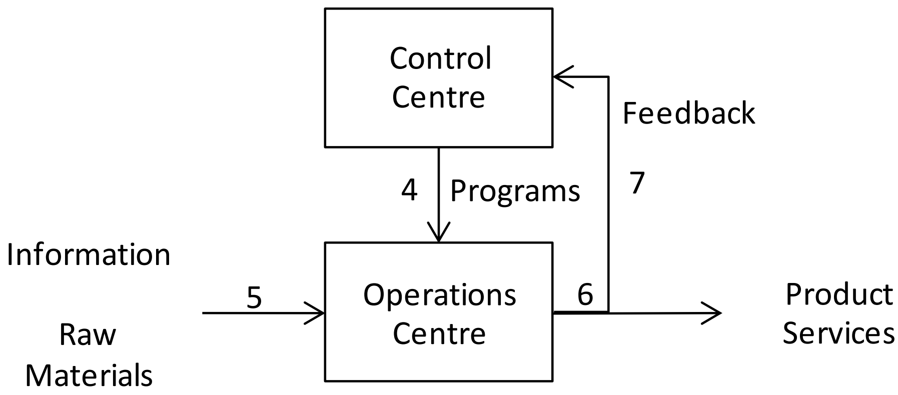


Figure 2-13 - Modified (Truncated) Model of Cybernetic System

(Truncated by Author - Scott 1992, p81, adapted from model by Swinth)

The performance management system is the process a company uses to manage performance in respect of organisational level strategy and goals (Leeuw & Berg 2011). It can be considered to incorporate five central themes. These are objectives, plans for their attainment, target-setting, reward structures, and finally information feedback loops (Otley 1999). This definition implies a linkage between strategic planning, management control and operational control, whereas often in the past these three areas have been treated as being independent of each other (Otley 1999).

A contingency approach recognises there is not one right way to structure performance management systems, but that there should be coherence between the three elements; strategic planning, management control and operational control (Bititci et al. 2016). The notion of "fit" is relevant here, recognising that the challenge is often in balancing the contingent demands of the operating environment with the extent to which a mismatch between the current organisational processes would be tolerated by the organisational stakeholders (Markus & Robey 1983). Strategic planning, management control and operational control are dynamically interwoven not only to affect control but also to initiate and sustain change (Leeuw & Berg 2011). This relationship highlights the importance of getting visual communication right and at the same time the difficulty of doing so.

It has been argued that the effectiveness of the system is to a greater or lesser extent dependant on how well the system is implemented (Dumond 1994). A poorly considered system, for example static performance measures, could result in local optimization by individuals or sub-elements within the organisation providing for locally efficient but organisationally ineffective behaviours (Leeuw & Berg 2011, Neely et al. 1997). From a visual communication perspective, as part of a performance management system, the targets and measures that are visualised must be aligned through an effective process. This is to ensure coherence and delivery of the strategy (Bateman et al. 2016, Bourne et al. 2000, Lee & Dale 1998), whilst remaining dynamic in the face of competition (Bititci et al. 2000).

Some of the obstacles to defining coherent performance measures, which align metrics at a strategic, tactical and operational level, are said to be the current lack of useful structured frameworks (Bhagwat & Sharma 2007). This is summed up by Bititci et al. (2000) who spoke about this gap in knowledge, and stated that this effectively means that it is difficult for organisations to "differentiate between improvement and control measures, develop causal relationships between competitive and strategic objectives and processes and activities...effectively and efficiently manage the dynamics of their performance measurement systems, [and] ...quantify the relationships between measures within a system" (Bititci et al. 2000, p695, words in square brackets added by the author).

One challenge at the level of the shop-floor is the need to align behaviours with the higher level organisational goals, i.e. the need to meaningfully cascade organisational objectives (Mascheck et al. 2013). There is the risk that the objectives, and potentially the overall strategy, can become diluted in an attempt to make them actionable at the respective levels. The phrase "abstractness versus concreteness" (Lee & Dale 1998) mentioned earlier is in recognition of the tension between employees at each level of the organisation acknowledging their respective objectives but these same objectives when cascaded to the next lower level of the hierarchy could be interpreted as being too abstract.

Tools such as the "consistency matrix" or "X matrix", shown in Figure 2-14 below are utilised as a visual device to affect and demonstrate correlation between the strategic level goals, the operational level tactics and the business processes that are impacted. They are used in an attempt to connect the aims, objectives, actions and measures of the organisation.

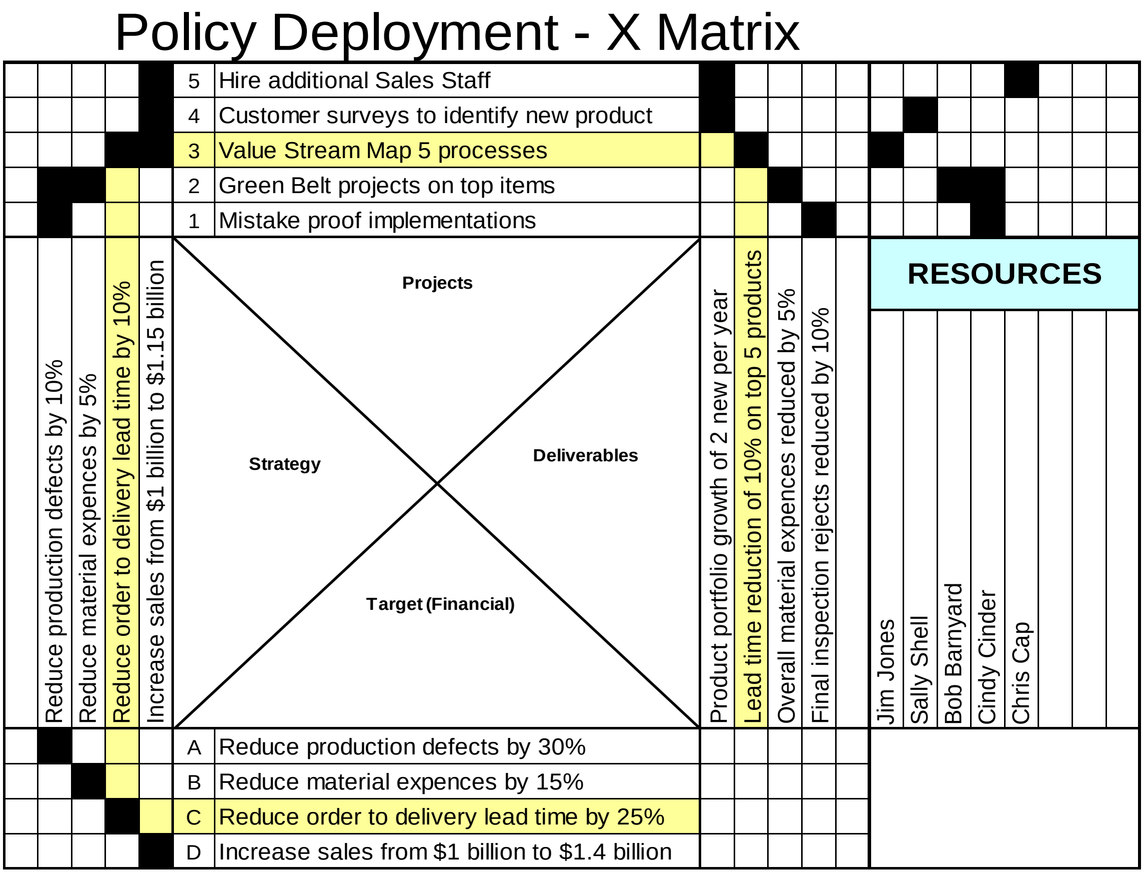


Figure 2-14 - X Matrix – Checking Consistency of Objectives.

(Diagram is an example from Automotive UK – but has been anonymised. The strategic goals are correlated with departmental objectives, targets and metrics to visualise and ensure consistency)

However, this tool suffers from a range of problems mainly associated with the subjective nature of the goals translation process as well as the subjective nature of how correlation is validated. A list of criticisms are given by Mascheck et al. (2013, p5), who stated that "...goals remain rather unspecific and generic...goals are not derived scientifically or based on a consistent set of rules...goals correlations to those one level up in the hierarchy get evaluated subjectively...interactions or tradeoffs between goals are not considered". The relevance of this to visual communication is that there are additional translation (encoding / decoding processes) when cascading objectives using visual means which could result in yet further dilution and dislocation from their original intended strategic purpose.

One aspect is ensuring that the goals are aligned whilst another is how to measure those goals. Directly connected to the cascading of strategic goals at the “macro” level with the goals at the “micro level” is the need to ensure coherence of the Key Performance Indicators (KPI’s) (Bessant & Francis 1999). These measures are intended to communicate with individuals and groups to ensure that there is a momentum towards the intended strategy. However, a settled approach for this translation process is missing (Mascheck et al. 2013).

Focusing specifically on those in the hierarchy that are engaged in operations, there is a need for information cascaded from the plant objectives that facilitates their decision making (Fullerton et al. 2014). Traditionally within business management systems there has been the use of financial performance measures, often drawn from a functionalist perspective, and adopted from economic theory. Here the focus has been typically orientated to performance measurement as opposed to performance management (Otley 1999). This can also be explained by the terms leading and lagging measures. A leading measure is used to predict an outcome whereas a lagging measure is a measure associated with the outcome itself (Kaplan & Norton 1996).

An example of using a combination of leading and lagging measures is provided by the concept of the balanced scorecard (Kaplan & Norton 1992). This proposed that at least at the executive level, a variety of measures and metrics provide protection against a myopic view on only financial data, possibly resulting in suboptimal performance. Kaplan & Norton (1992) petitioned for a view across a range of both financial and operational metrics. These are focused on recognizing the firm’s performance from a customer perspective, i.e. measuring the organisations critical processes and competencies, understanding the organisations capacity to continue to create customer value and finally being aware of the creation of shareholder value (Kaplan & Norton 2001).

Bhagwat & Sharma (2007) characterise these metrics as comprising:

- Short term / Long term objectives,
- Financial / Non-Financial measures,
- Leading / Lagging Indicators,
- Internal / External performance measures.

In accepting that strategy should be meaningfully cascaded using a range of financial and operational metrics at the executive level, it seems conceivable that there should be an expectation to find these themes contained in the metrics at the shop-floor level. Likewise these themes would potentially be found as the motivation for the use of particular visual communication elements.

Despite Kaplan & Norton (1992) predominantly being focussed at an executive level, it is interesting to identify the types of measures being deployed, how they are characterised, and their relevance to visual communication. In the same way that the cybernetic organisational perspective depicts the inputs, process, and output components of the organisation (see Figure 2-13), similarly metrics can be corresponding associated with each of these three components. There is also a need, consistent with the hierarchy (Jaques 1990), to have short, medium and long term measures, and furthermore there can be a combination of financial and non financial measures in each case. This highlights the complex needs for communication, to which visual communication can also contribute.

At a basic level however there may be some common themes that would necessarily emerge just because of the nature of the shop-floor. This would be despite whether strategy is effectively or otherwise cascaded. In accepting the assertion that capacity, inventory and demand information are primary imperatives in a mass production shop-floor (Schmidt 2005, Thompson 2004), at minimum there can be an expectation to find these connected to the use of visual communication (Nash 2004, Bessant & Francis 1999).

2.9 Conclusion

In this review of literature, I have considered the organisational perspective that is suitable for this research. This helps to establish the context within which visual communication is being used. In addition, by looking at the control types used in organisations, I have identified those that are most likely to be found at the level of the shop-floor in the specific type (Thompson 2004) of organisation in which this research has been conducted.

Next, by exploring taxonomical frameworks that are related to the research aims, and by comparing and contrasting several different models, I have identified the broad themes that can be expected to be found on the shop-floor. These provide a range of themes that can be contrasted with what emerges from this research.

I also briefly introduced the thinking behind socio-technical system theory. This rebalances the design of the organisation from one based purely on the needs of the primary tasks to one which also considers the needs of those individuals performing them. It shifts the perspective from a modernist to a neo-modernist view, where the socio-psychological needs of organisational members are seen as a dependant variable for successful organisational design. It is relevant to consider this perspective, as this research explores a way (visual communication) in which people are integrated together with these task requirements.

Finally I have looked at visual communication from a performance management systems perspective to understand how visual communication is being used and also some of the potential problems with ensuring it is consistent within such a system.

The key issues identified in this review were;

In a mass production environment there are some key shop-floor related imperatives that are said to motivate the way in which communication is being used, i.e. inventory, capacity, demand information (Schmidt 2005, Thompson 2004). These three generic themes can be related to the cybernetic system perspective and highlight the complex uses for which visual communication is employed, i.e. measures that are leading and lagging, those that are for the short, medium or long-term, and financial and none financial.

This view of visual communication is also captured to an extent by literature relating to the use of policy deployment (Lee & Dale 1998). This effectively connects strategic planning, management control and operational control (Otley 1999). Here, visual communication as part of the broader cybernetic process is being used to display cascaded goals, as well as to track and affect those goals (Leeuw & Berg 2011).

Continuing with the cybernetic perspective, in a mass production environment there is a need for management to affect control of the shop-floor. In such environments the predominant controls are predicted to be bureaucratic and output types (McAuley et al. 2014). However, issues such as de-layering may mean that all three types (bureaucratic, output and cultural) are operating simultaneously at the level of the shop-floor. Visual communication is being used to affect control of the shop-floor and arguably is affecting control in accordance with these three types (Jaca et al. 2014, Greif 1991).

Existing visual communication models (taxonomy) were reviewed and some common themes were identified (Jaca et al. 2014, Galsworth 2004, Mestre et al. 2000, Greif 1991). The identification of these was necessary to provide some theoretical basis for comparing and contrasting the findings; ensuring that they are connected to theory (Fransella & Bannister 1977).

These visual communications models have a great deal in common when compared back to back. However, some elements such as contextual variables relating to national culture, i.e. time, space and context, are absent. In this research, as a single case study, these themes were not assessed, although contingent needs from different value streams did become apparent, as will be discussed in the findings and discussion chapters.

In the next chapter I have identified the design and methods that were used to achieve the research aim and objectives. These have been built on the foundations of the Shannon & Weaver (1949) Communication Model. Using this model I was able to identify methods that enabled me to correlate between the intended and interpreted meanings in relation to selected examples of visual communication. This has been done in a way that was sympathetic to the issues raised in this review of literature. One example of this is recognising that it was necessary to access the motivation behind the use of visual communication within its situated context. A second example is the need to recognise the differentiated social structure of the organisation, called value streams. These value streams are consistent with the semi-autonomous work groups espoused by the socio-technical system theory perspective. These social groups support individual continuous flow production cells (Liker 2003), which have been created according to specific task needs. It is necessary to ensure that the research design can capture the intended and interpreted meaning of visual communication within these unique task and socio-technical settings. Finally the literature review has also been used to validate the findings by correlating the usage of visual communication with the expectations from literature.

3 Research Methodology & Design

In this chapter I have detailed the methodological approach, the research design and methods, as well as showing how these have been aligned according to the conceptual model. The aim of this was to enable access to the correlation between the intended and interpreted meaning in relation to specific examples of visual communication taken from the shop-floor at Automotive UK. I have also provided a detailed account of the data gathering for the research as well as a short summary of a pilot study that was conducted.

3.1 Research Methodology – Neo Empiricist

It is important at this point to state my ontological and epistemological commitments as these have informed my approach to answering the specific questions within this study. More generally it is the way I have engaged with this organisational research (Gill & Johnson 2010). These 'commitments' are important in that they "...are a key feature of our pre-understandings which influence how we make things intelligible" (Johnson & Duberley 2000, p1).

Ontology is a philosophical question about what constitutes reality (Scotland 2012). Do things exist in reality so that they are “out there” (McAuley et al. 2014, p11) or are these perceived things just products of our minds? In terms of social research they are specifically questions about the social world and how it is perceived and understood (Hughes & Sharrock 2007, Behling 1980). This debate is important because the position adopted within these philosophies, either as a belief or as a pragmatic decision, influences the approach taken towards research; each of these different beliefs about reality in turn giving rise to different organisational perspectives. These various perspectives (vantage points) for observing organisations, and the assertions made within literature from one perspective, can often be contradicted by literature stemming from another approach (Scott 1992).

As a professional Engineer since 1991 I am predisposed towards a realist ontological view of the world. This is a view that there is a reality out there and it is independent of us as observers (McAuley et al. 2014), i.e. the “truth” of the organisation is there to be seen, we just need to figure out how to look. During the last 12 years, as an engineer and manager, I have worked in a global role as an internal consultant. I have applied Lean methods (Towill 2010) for organisational transformation across many different sites located in different parts of the world. I am employed to make interventions and consider that being action orientated is critical for me personally and my role within the organisation. I see that my realist ontology is somewhat predictable based on the job that I do. Also my world view to some extents makes it predictable that I would do this type of job.

There are ongoing debates about the validity or truthfulness of taking this realist view of organisations (Johnson & Duberley 2000). I view the social world of the organisation as a messy version of the natural world. Organisational reality is noisy and difficult to bound but I do not see organisational phenomena as being something that is created in my mind and unique to my perception. It is not aside from the natural world but for me is just a part of it. I believe I am able to perceive aspects of the organisations reality and that beyond this I am able to make interventions to this reality that are effective at achieving broadly the results that were anticipated. As such this objective ontology sets the scene for the research design and methods (Crotty 1998) and arguably even the problem that I have sought to research.

In conducting this research, in an effort to answer my central question, it was necessary to access the interpretation of reality by managers at Automotive UK, whilst remaining independent of the research findings. I employed methods that have led "…to provide an account of the other's organisational experience" (Johnson & Duberley 2000, p181). To access these interpretations the research approach has had to capture the meanings given to specific visual communication within their contextual setting (Jappy 2013). Consistent with my specific overall orientation to research this has been conducted from a neo-positivistic theoretical perspective (Crotty 1998).

Neo-positivism, along with Positivism, shares the commitment that to get knowledge about a phenomenon then it must be accessed using our senses. Both camps agree that this is the only way to access knowledge about the natural world, and apply the same conditions to the social world of organisations (Johnson & Duberley 2000). There is however an important difference between positivism and neo-positivism. Neo-positivism holds that to understand human behaviour in organisations we must access the interpretation of those within organisations of their perceived reality. This means using suitable methods for accessing their subjective interpretation of that reality. Neo-positivists, such as myself, would argue and believe that through the correct deployment of research methods it is possible to utilise subjective data, provided by those inside organisations, to make objective observations about what is going on in that organisation in respect of specific phenomena (Johnson & Duberley 2000).

I considered the neo-positivist approach was suited to this research for at least two reasons. Firstly, it recognised that the meaning of visual communication at Automotive UK is affected by its social context and cannot be understood in its absence (Kenney 2009). This is consistent with the research approach I have taken which was to conduct the research within its situated context, using actual examples of visual communication, and accessing the intended and interpreted meanings directly from those individuals between whom the visual communication was being used.

Secondly, the research has been conducted in an organisation of which I am part and I recognised the possibility of influencing the research findings (Symon & Cassell 2012), which I have discussed further in the next section. As such I have employed a research design and methods that impartially capture the way in which visual communication was working at Automotive UK. This was achieved using a mixed qualitative and quantitative approach with a particular focus on participatory methods to capture the intended and interpreted meaning directly from those using visual communication. Only subsequent to establishing an objective correlation using quantitative surveys methods have I provided my interpretation of the results. Although my observations of the data are subjective, I have tried to inform this subjectivity through the theoretical perspectives established in the literature review, i.e. taxonomical frameworks, cybernetics systems, control and performance management systems.

This neo-positivist orientation underpinned my decision to use a case study research strategy to access the intended meaning and subsequent interpretation of visual communication.

3.2 Reflection

Neo-positivist research, similar to positivism, has as its heart two embedded significant philosophical assumptions. These are:

> “That there exists an independent social reality, out there, awaiting our inspection, through the deployment of a suitable methodology"
>
> "That it is possible to neutrally gather data without contaminating them through the very act of observation”.
>
> (Gill & Johnson 2010, p188)

The first of these assumptions is taken for granted within positivist research and does not need to be further debated here. However the capacity to gather data as an observer, without contaminating it, or at least recognising the extent to which there can be bias, is important. In this section I have critiqued my role as researcher versus my role as employee of the same company, and how this has the potential to impact this research. It is argued that researchers can be objective to a greater or lesser degree; that by bringing their own social, cultural and political interests (Symon & Cassell 2012, Brannick & Coghlan 2006) to the research they are in fact part of what they observe (Gill & Johnson 2010). This is said to be especially true in the case of conducting research in one’s own organisation. Reflexivity is the exploration and attention to the relationship between the researcher and the object of research. It is making explicit the "...personal experiences, belief systems, motivations and tensions, as well as political agendas...continually assessing the impact these factors may be having on the research endeavours" (Brannick & Coghlan 2006, p145).

There are two types of reflexivity (Gill & Johnson 2010). One type relates to epistemic reflexivity. This is where the researcher attempts to unearth and challenge their own internalised presuppositions that could impact how they structure, conduct and subsequently interpret research activity (Gill & Johnson 2010). The second type relates to methodological reflexivity, which is an evaluation of the protocols that are followed to ensure that the researcher does not inadvertently bias the results. The aim of such reflexivity is "...to improve research practice through the facilitation of a more accurate representation of reality via the eradication of methodological lapses …" (Gill & Johnson 2000, p178). Within neo-positivist research the reflexivity is limited to methodological reflexivity (Gill & Johnson 2010) and that is what I have presented below.

The organisation I work for has a corporate structure comprising more than one hundred individual manufacturing sites. These have been divided into groups of companies producing similar products. I work for one such group comprising 17 individual sites, of which I currently support five, based in China, South Africa, Czech Republic and the UK.

From a reflexive perspective one important issue that helps to characterise the influence of my role in the context of this research is if I am an ‘insider’ or ‘outsider’ (Brannick & Coghlan 2007) to Automotive UK. An insider is someone who is seen to be an organisational member, being subjected to the organisation’s systems, whereas an outsider is seen to be independent. I have a longstanding relationship with the five plants I currently support, having worked with them between three and twelve years. My role as a corporate resource, tasked to work with management teams within the sites, but not directly part of those management teams, means that I straddle somewhere between the insider / outsider continuum. However, I personally try to maintain a bias towards being an outsider. I encourage this view of me to ensure that others see me, and I consider myself as being independent of the site. I do this in an attempt to remain objective with advice and interventions. I think this has helped when conducting this research as my perception was that I was seen as behaving in a way consistent with how the organizational members have previously encountered me, i.e. an objective outsider. However, despite my best efforts to maintain an overtly positivist stance, this is still complicated by my role in the organisation, and the potentially conflicting need in this thesis to make an individual contribution to knowledge and practice (Zuber-Skerritt & Perry 2002). There are said to be a number of challenges for those conducting research in their own organisation, e.g. access, pre-understanding, role duality and organisational politics (Brannick and Coghlan 2007). I have structured the following part of this section according to these areas to engage in a discussion about their respective impact on the objectivity of this research. The subject of this reflexive critique is the extent to which I have done this successfully by deploying the methodological rigour necessary to remain objective, whilst at the same time benefiting from access and pre-understanding.

3.2.1 Access

I had the benefit of both primary and secondary access (Brannick & Coghlan 2007). This is respectively access to the organisation in its broader sense as well as to the specific system/sub-systems within the manufacturing site which were the focal point of this research.

I have worked with the organisation for a number of years and built a level of credibility with individuals within the management team. This has afforded me privileged access to various levels of the hierarchy. The fact that I am not part of the management structure, but an outsider from a role perspective, makes me seen, I believe, as relatively objective and neutral. However there is recognition that my reporting lines are to the same senior personal that the plant managers also report to. This could lead to some reservation in terms of what is revealed to me, but I personally correlate confidentiality with credibility, and the individual managers have had experience over a number of years that what they reveal to me would not get passed upwards to the hierarchy.

Additionally the subject of this research was not seen as being contentious. The organisation, as part of its Lean development, had made efforts to improve the visual management of the shop-floor. There was recognition by some members of the management team that communication on the shop-floor was problematic, and efforts should be made to improve it. The Human Resource Manager and Production Manager were two important stakeholders in the management team enabling the access to those I wanted to include in this research. My discussion with both these parties was met with positive comments and a commitment to support the research from the onset.

A further issue related to this topic is the difference between the formal and informal aspects of the organisation (Watson 2006), and my access to them. Negotiating with the management stakeholders provided the opportunity to access the formal aspects of the organisation and its hierarchy. However, my past association with the organisation as an initiator of potential change could have resulted in varying levels of cooperation and/or resistance. The granting by management of formal access may have simultaneously "…exclude[d] access to many informal and grapevine networks" (Brannick & Coghlan 2007, p67. Addition in square brackets added by the author). I did not consider this as detrimental to the research as I considered the use of the multiple methods for qualitative and quantitative data collection did not rely on revealing confidential or soft information by the participants.

3.2.2 Pre-understanding

Conducting research in an organisation which I have been associated with for some time also brings a different set of issues associated with objectivity. My relative familiarity of the "…routines, practices, people and processes" (Symon & Cassell 2012, p56) can arguably classify me as more 'insider' than 'outsider' (Brannick & Coghlan 2007) to this organisation. This correspondingly creates a range of benefits and challenges.

I had prior knowledge about the organisational structures, both in the way that the shop-floor had been differentiated into discrete value streams, and the social composition which was designed to support these physical areas. In fact I had been actively involved in facilitating the change to this structure from the previous functional layout (Liker 2003) with its relatively functional social structure (Woodward 1965) that preceded it around four years earlier. The creation of these structures was aimed to provide a greater focus of particular customers and product types (Rother & Shook 2003). This inside knowledge led me to particular decisions such as a nested case study design (Yin 2009). This was acknowledging my expectation that different value streams could exhibit different emphasis on different imperatives. Similarly it was insider knowledge about the prior usage of methods, such as participant-led-photography and the eliminate, combine, rearrange, simplify (ECRS) method within this organisation that encouraged me to use them in this more structured research setting. My use of scripted questions, defined protocols for photograph selection, random (alphabetical) selection of participants, and the use of methods to empower the voice of those involved in the research were all aimed to fulfill the role of 'investigator' (Yin 2009). It was through these methodological devices that I attempted to behave more as an 'outsider'.

3.2.3 Role Duality: Organisational and Researcher Roles

Throughout the various stages of the thesis I have tried to maintain a separation between my professional role in the organisation and my role as researcher, with the objective to avoid any conflict (Brannick & Coghlan 2007) with the aims of my direct manager and other senior managers. There are a number of examples of how I have tried to maintain this dual citizenship of the organisation. These are:

I prioritised activities related to my job first as opposed to my research. I worked on my thesis after 18:00 during the working week and additionally during the weekends. This was to avoid any conflict with my direct manager or other senior managers within the organisation about the use of my time and the balance between value added activity and research activity.

The data collection was conducted over a two week period using personal holidays. This was for similar reasons to the comments made above.

I maintained as much as possible a clear separation in my interest in the results of my research from any given area of the factory with those of my professional activities. This was particularly important as I am partly responsible for informing the organisation about the potential benefits of visual communication usage. As such I was conscious of potential bias due to having a vested interest in this topic. Recognising and remembering that this activity was research was helpful in countering any sense that I had to justify the outcome.

The most important point about my capacity to separate my organisational and research role was the framing of the central question itself. The core contribution of my research was to be a measurement instrument that could access hierarchically intended and subsequently acknowledged meaning of a given visual communication. The instrument and its capacity to measure was a barometer of the success of the research, and not the particular result of correlation within any or all of the value streams. As such it was relatively easy to separate myself from the core research activity and my professional role. Also I felt there was no conflict in writing up objectively what I encountered, as these discussions and findings were based on the use of the measurement instrument.

3.2.4 <u>Managing Organisational Politics</u>

The final area of discussion relates to the perceived conflict that could arise from the potential differences between the aims of the research and the respective power and interest of key stakeholders (Brannick & Coghlan 2007). The broad alignment of my research focus with the perceived needs of the research organisation, avoided any overt conflict with key stakeholders mentioned above, i.e. Human Resource Manager and Production Manager. It was also seen as consistent with my normal professional role in the organisation, which involves the dissemination of practices relating to topics such as visual communication.

My direct manager was politically neutral in terms of endorsing or resisting the research. He saw it as something that I was interested in doing, in so far as it did not interfere with my 'day job' then he did not need to intervene. This meant from a hierarchical level I did not have to justify the research topic, or to feedback progress or planed next steps. Also of great significance, I was not asked to demonstrate any organisational or financial benefit for the research. The central question of the research was my choice and I was left to conduct it in a politically benign climate.

I have already mentioned above the usage of personal holidays and out of hours working to avoid the potential for conflict and unnecessary senior management interest in my research. In addition, the amount of time I needed with managers and operators to conduct interviews posed a risk that could potentially derail my data gathering. The members of the management team might protest and withhold access to the operators, thwarting my attempts to gather the data in a relaxed way. It was this consideration that led me to make several decisions regarding the methods used and field work protocols:

- Limiting the number of elements for photo-elicitation to six.
- Limiting the number of questions in the survey to ten.
- Limiting the number of photographs rated using the questionnaire.
- Limiting the number of operators per value stream to three.
- Collecting relatively limited soft data in the form of comments.

3.2.5 Conclusion

In the above discussion I have considered the issues arising specifically because I have conducted research in an organisation of which I am a member. Using the potentials areas of conflict highlighted by Brannick & Coghlan (2007) I have considered my dual role, and the impacts this had on my capacity to effectively deploy the research methods.

Acting as an internal consultant, supporting Automotive for a number of years, has provided some benefits but also risks to this research. Although I am not a full time member of the organisation, I cannot be truly classified as a complete outsider. From this perspective I retain a level of separation from the plant which I believe has enabled me to adopt a positivist 'distance' stance. However, it has still afforded me the access that I needed.

My prior knowledge of working with Automotive UK had many benefits. I knew of, and had credibility with, the key gatekeepers to the organisational areas that I wanted access to, and with their blessing I was able to conduct the research in a politically neutral climate. This perceived sponsorship by the functional managers also encouraged those being asked to engage directly in the research to cooperate with the data gathering activity. My familiarity with the organisation and its specific internal structures was important for specific research decisions, e.g. using a nested case study in recognition of the differentiated shop-floor design. However, it also created some potential risks in taking things for granted and not question underlying assumptions that could help to reframe the issues (Brannick & Coghlan 2007). Overall I felt that being an organisational member enabled this research to be designed and conducted in a coherent way. However the need to navigate the challenges of doing research within one’s own organisation were also highlighted.

3.3 Conceptual Model

The design of this research has been based on a premise that the use of visual communication on the shop-floor is in the context of a hierarchical bureaucratic organisation. This is important to mention because it highlights the underpinning assumption in the research design, i.e. that visual communication we see on the shop-floor is motivated in the first instance by some thought in the mind of the manager.

As discussed in the literature review, communication models are argued to consist of some basic process steps (Watson & Hill 2012). These are that "…the communication process begins when a message is conceived by a sender. It is then encoded – translated into a signal or sequence of signals – and transmitted via a particular medium or channel to a receiver, who then decodes it" (Watson & Hill 2012, p48). The Shannon & Weaver (1949) Communication Systems Model views communication according to this systems perspective (Jones & Kovac 2003). As I have shown earlier, I have modified this original model by replacing the original headings to depict the communication process as it is related to this research project. Please see Figure 3-1 (below). Shown in the upper part of this diagram is the manager on the left and the operator on the right. It is the correlation of the intended and interpreted meaning of communication between these two individuals, through the use of visual communication, that is the aim of this research design.

In the bottom half of the figure I have shown the modified Shannon & Weaver (1949) Communication Model. This is to indicate how the intended meaning from the information source (manager) flows through various process steps until it reaches the destination (operator).

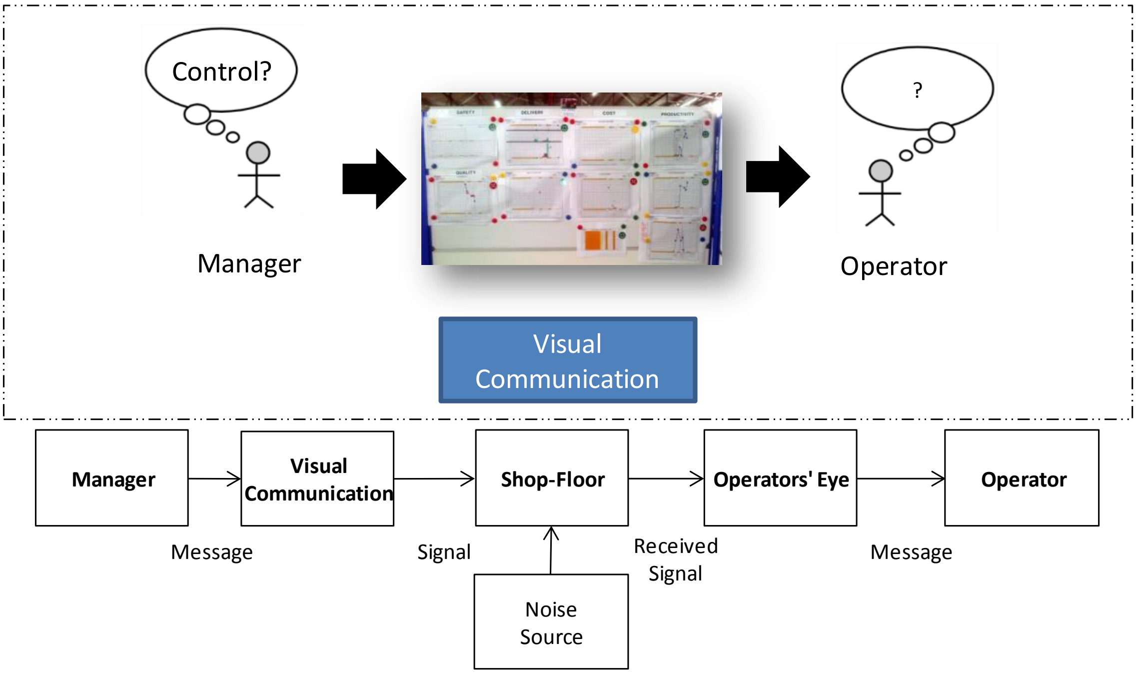


Figure 3-1 – Modified Shannon & Weaver Model – Conceptual Structure

(Based on the Shannon & Weaver (1949) Communication Model)

There are two elements to the research design based on this conceptual model. One is the use of the Repertory Grid Analysis (Fransella & Bannister 1977) and the second is how this has been structured within a Case Study approach (Yin 2009).

I will firstly explain the use of the Repertory Grid Analysis design. This in turn will help to explain how the features of a Repertory Grid Design have been aligned with the above conceptual model.

3.4 Research Design

3.4.1 Repertory Grid Analysis - Design

Repertory Grid Analysis is an approach used to elicit psychological constructs (Partington 2002) from individuals and groups. Repertory Grid Analysis classically involves structured interviews with individuals. These interviews are used to elicit an interviewee's personal constructs, to explore the views of an individual at a level that the interviewee is probably unaware of. In this research I used the Repertory Grid Analysis design to elicit the manager's psychological constructs which are motivating their use of visual communication. I subsequently operationalised these psychological constructs to enable the evaluation of a range of examples of visual communication. With these aims in mind the Repertory Grid Analysis approach provided a tailor made design suited to the aims of this research.

The use of the Repertory Grid Analysis design to gather qualitative and quantitative data is consistent with what is described as mixed methods (Gill & Johnson 2010, Yin 2009). This is when in the same research there is a combination of quantitative and qualitative methods and the researcher accepts the relevance of both subjective and objective data in the role of social science research (Gill & Johnson 2010).

Repertory Grid Analysis was developed in the 1950's (Goffin et al. 2010). It is a way of exploring the implicit theories people use to make judgements about the world (Fransella & Bannister 1977). George Kelly, the inventor of Repertory Grid Analysis technique argued that in trying to make sense of the world people develop rules. These personal theories or rules of judgement of individuals are called ‘constructs’ and they are used by individuals to make sense of their engagement with the world (Kelly 1963). It is a way for individuals of explaining events (Goffin et al. 2010); about how "living creatures derive meaning from their world by seeing similarities and differences between events and construing their replications..." (Fransella & Bannister 1977, p56).

Constructs are said to be constantly revised to match our everyday experiences and they are said to be impacted by social contexts (Kelly 1963). This assertion is important to this research. The research methods have stratified the data collection and subsequent analysis across different departments of the organisation (value streams). This design was specified to capture the common as well as the unique constructs (Goffin et al. 2010) that were operating at the shop-floor within Automotive UK.

Repertory Grid Analysis, although originally developed for application to individuals, has also been applied to groups (Bauman 2015, Alexander et al. 2010, Pike 2007). This requires the identification of suitable methods to take the various responses from individuals and to categorise and group them to identify their similarities. This issue and the methods used to deal with this are discussed later in this chapter.

In keeping with a neo-positivist approach, the Repertory Grid Analysis is compatible with participatory research. It is a mode of investigation which encourages participants to use their natural language which is relevant to the subject being investigated (Banister et al. 2011, Pike 2007). Since the introduction of the Repertory Grid Analysis technique, many modifications have been made by researchers to its design and application. Fransella & Bannister (1977) describe a number of these different approaches but state that the way in which Repertory Grid Analysis can be used is limited only by the imagination. In a review of Repertory Grid Analysis research the majority of business applications have been related to the tourism industry (Pike & Kotsi 2016, Hankinson 2004). Tourist destination images have been used in the study of travel behaviours for a number of years. Whilst typically this has involved eliciting constructs related to designative images (preferences), there are also examples of research relating to website design, where Repertory Grid Analysis has been used to evaluate the content of the images themselves (Bauman 2015). This latter research was more relevant to the research that I have conducted here where I was interested in the content components of examples of visual communication taken from the shop-floor environment.

There are three core features of the Repertory Grid Analysis technique that are common and remain constant irrespective of any modifications (Bauman 2015, Winter 2013). These are Elements, Constructs and Evaluation, shown below in Figure 3-2. In the next part of this section I will briefly describe each of these component parts and explain how they are aligned with the overall conceptual model.

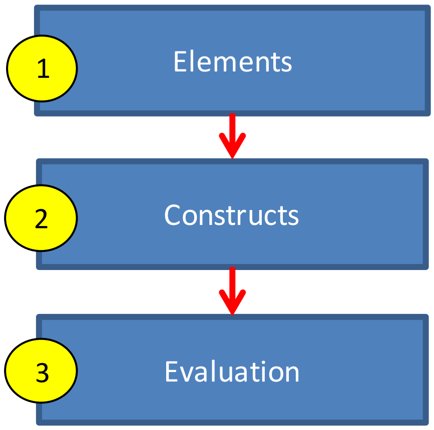


Figure 3-2 – Elements of Repertory Grid Analysis

Elements - these are a set of items (people or objects) that are to be evaluated. They can be provided by the researcher or, as in this research, gathered by those who will be later asked to identify their constructs, i.e. managers. For this research these elements were a number of photographs of visual communication currently used on the shop-floor. I have aligned the box marked 'elements' (Figure 3-3 below) with the central box from the modified Shannon & Weaver (1949) model. This box denotes the channel that is being used to transmit the communication, and it was from here (locations on the shop-floor) that the managers themselves selected example of visual communication.

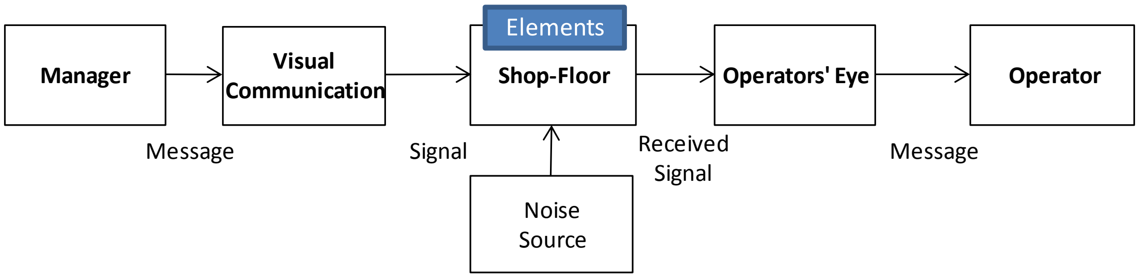


Figure 3-3 - Alignment of Repertory Grid Analysis and Conceptual Model

(Based on the Shannon & Weaver (1949) Communication Model)

Constructs - A number of different techniques exist to help solicit the constructs from whoever is participating in the research. These are the "explanations of [the] elements characteristics" (Bauman 2015, p369, words in brackets added by the author). In this research these constructs were elicited directly from the managers in relation to the photographs (mentioned above) that they had themselves captured of visual communication being used in their respective production areas (see Figure 3-4 below). This part of the Repertory Grid Analysis technique was designed to capture the psychological constructs that managers were using in respect of visual communication, i.e. what do the managers think is their motivation for using particular visual communication. A useful aspect about the way in which these constructs are elicited and gathered is Kelly's' assertion that these constructs are necessarily bi-polar (dichotomous). This feature lends itself favourably to the next step which is the evaluation.

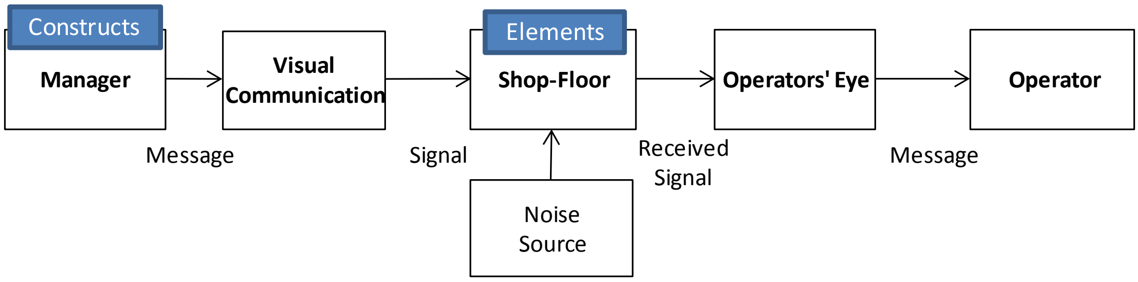


Figure 3-4 – Alignment of Repertory Grid Analysis and Conceptual Model

(Based on the Shannon & Weaver (1949) Communication Model)

Evaluation - The bi-polarity of the elicited constructs enables them to be readily used to create an evaluation tool, i.e. a bi-polar questionnaire. Once created, this questionnaire was administered to a number of managers and operators from across the different production areas. It was used to rate a number of current examples of visual communication from the shop-floor. The comparison of the results of this questionnaire (see Figure 3-5 below) is what enabled the measurement and comparison of the intended and interpreted meaning of visual communication to be explored and assessed, allowing this research to achieve its aim.

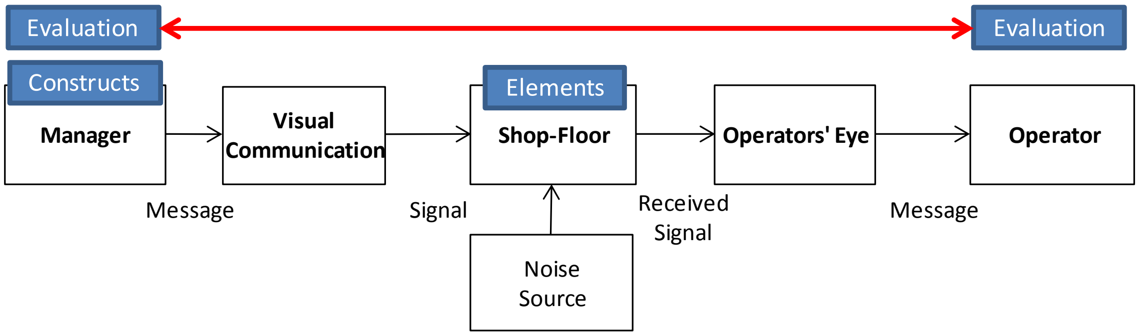


Figure 3-5 - Alignment of Repertory Grid Analysis and Conceptual Model

(Based on the Shannon & Weaver (1949) Communication Model)

3.4.2 Research Design - Case Study

The design adopted in this research was consistent with the single case study (Yin 2009), where the intention is to conduct the entire research within a single location. The key reason for selecting a case study approach was the wish to conduct the research in the environment within which the visual communication was being used; consistent with a neo-positivist approach. The case study approach is said to be useful when it is difficult to implement experimental control (Gray 2004). The use of this approach allowed the managers in the organisation to self-select the visual communication examples that would be used for this research and to attach their own meaning. I considered this to be necessary to expose the meaning of visual communication and its subsequent interpretation within its natural, socio-cultural context (Seppanen & Valiverronen 2003).

As previously described in the introduction, Automotive UK was a relatively large company, with c.+400 employees. The product portfolio consisted of more than 500 part numbers, divided into six different product families (Rother et al. 2003). Figure 3-6 below depicts the layout, with the six production areas highlighted. These six differentiated production areas can also be referred to as value streams (Bititci et al. 2016, Liker 2003, Rother et al. 2003). All six were included in this case study and represented 100% of the turnover of the site.

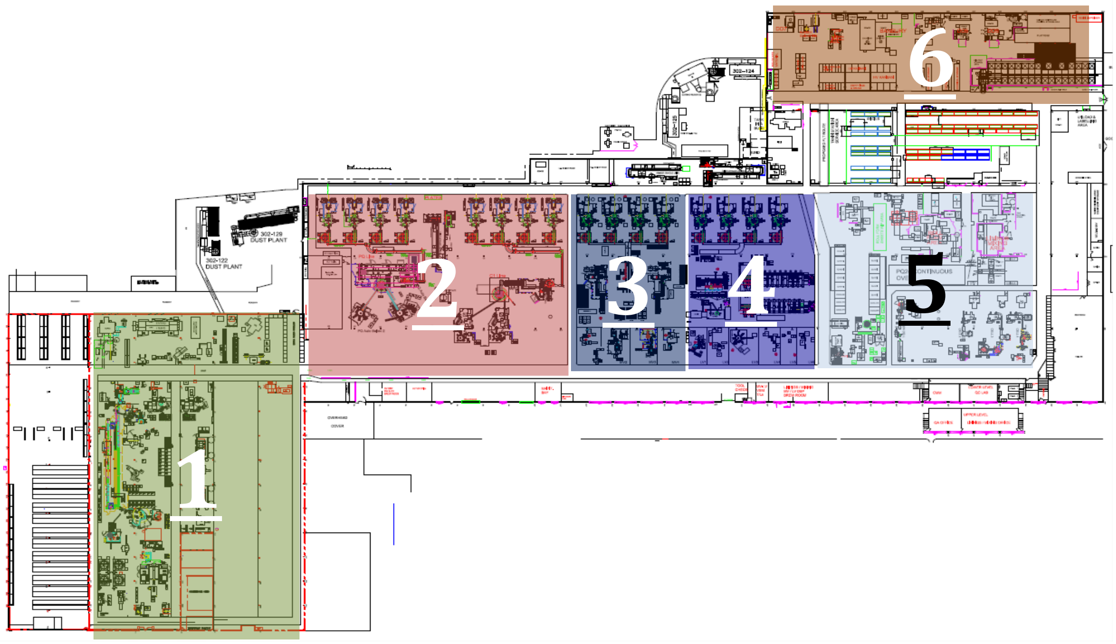


Figure 3-6 – Product Family Layout at Automotive UK

Figure 3-7 shown below depicts how the social organisation at Automotive UK had also been structured into discrete value streams; discrete hierarchical management teams managing their individual value streams.

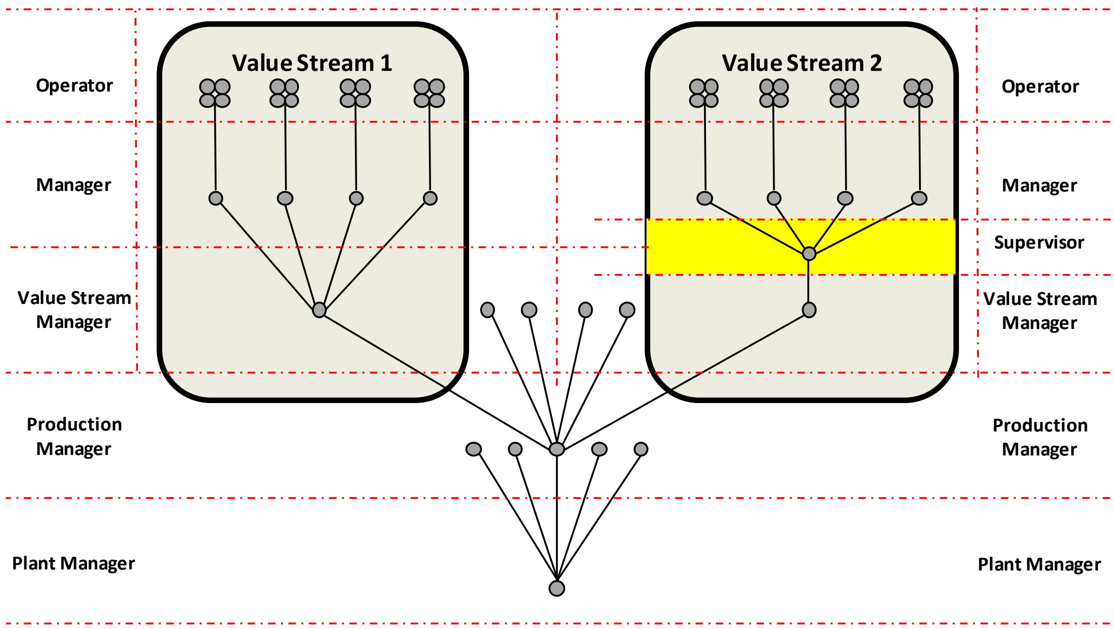


Figure 3-7 – Organisational Structure

(Based on diagram by Liker 2003, p192)

Of the six different production areas, five were structured as shown on the left side of the diagram above, i.e. four management tiers. The sixth production area had an additional management level, which I have shown on the right side of diagram. I have highlighted an additional supervisory level. This difference is relevant to the pilot study that I conducted and will be discussed again later.

Case study research carries health warnings like most research approaches. Yin (2009), particularly referring to multiple-case holistic studies, warned of the risks where the results of the first study may inadvertently shift the question being investigated in the mind of the researcher. These risks are also relevant when conducting a single-case embedded study. As this research was being conducted, with the need to consider any reappraisal of methods, it was necessary for me to reflect back on any required adjustments and their impact in respect of achieving the research aim and objectives. As a single case study, unique and common problems were difficult to separate. However this did not prevent methodological reflexivity (Coule 2013, Gill & Johnson 2010, Johnson & Duberley 2000), which forms part of the discussion chapter.

Another health warning is that when relying on a single or small number of samples, there is a risk that they may not be representative of the phenomena under investigation. They may provide limited (Symon & Cassell 2012) or perhaps misleading evidence. I considered this problem important as it seemed very central to the argument against using a single case study. However, dependant on the sampling procedure and sample size, the data I gathered would still be representative of the particular case (Eisenhardt 1989), i.e. demonstrating a methodological approach which if shown to work with this and subsequent cases, would inform practice. Although not immediately generalisable, it would still have allowed a local understanding of how visual communication was working in Automotive UK. As such it could be used to inform management practice of how to optimise visual communication there. It could then be repeated in different sites to uniquely inform their communication efficiency.

3.5 Research Methods

Within this case study, two key methods were used that enabled me to structure my research according to the Repertory Grid Analysis design. This first of these was the use of a Focus Group and this was followed by the use of a Survey.

3.5.1 Focus Groups

In Figure 3-8 below I have shown how, consistent with the Repertory Grid Analysis approach, the research was split into two phases, shown by the two boxes on the right (‘Focus Group’ and ‘Survey Research’). In this section I have described the use of focus groups and defined the three data collection methods utilised. Following this in the next section I have described the use of the survey methods and the associated data collection method.

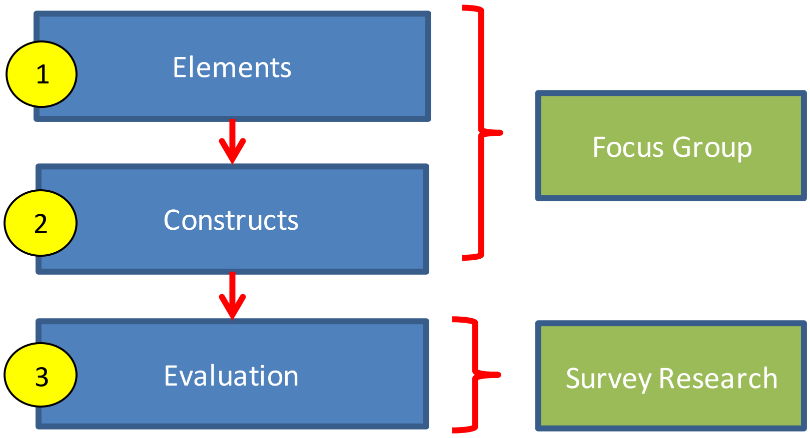


Figure 3-8 – Research Methods – Repertory Grid Design

There are at least three different approaches used with focus groups (Calder 1977, p355). The first is the exploratory approach which is typically used to "...generate scientific constructs and to validate them against the everyday experience". The second is the psychological approach which is the “use [of] second-degree scientific constructs without numerical measurement...”. Finally there is the phenomenological approach which is aimed to "...understand the everyday experience of the consumer" (Calder 1977, p355). In this research I have used focus group methods that rely on structured interviews, which is aligned with the psychological approach described above by Calder (1977).

The selection of the individuals or groups that constitute the focus group is important as this is used to represent the population under study. Four key points that are said to be important when defining the samples for qualitative research have been highlighted by Robinson (2014). I have listed these in Figure 3-9 below. Highlighted in the final column, I have explained the approach taken in this research.

Name	Definition	Key Decisional Issues	Research Choice for this Research
Point 1 - Define a sample universe	Establish a sample universe, specifically by way of a set of inclusion and/or exclusion criteria	Homogeneity vs. Heterogeneity, inclusion and exclusion criteria	Managers (hierarchically the ordinates of the shop-floor operators).
Point 2 - Decide on a sample size	Choose a sample size or sample size range, by taking into account what is ideal *and* what is practical	Idiographic (small) vs. Nomothetic (large)	Idiographic sample = 6 individuals
Point 3 - Devise a sample strategy	Select a purposive sampling strategy to specify categories of person to be included in the sample	Stratified, cell, quota, theoretical strategies	Stratified - according to value streams. One per value stream.
Point 4 - Source the sample	Recruit participants from the target population	Incentives versus no incentive, snowball sampling varieties, advertising	Expectation to participate

Figure 3-9 – Four Point Approach to Sampling

(Robinson 2014, p2)

These points are further elaborated below to explain how the managers across different value streams and shift patterns were selected.

Sample Universe - The sample universe was the identification of the total population that could be considered for inclusion within the research. For Automotive UK this population total was eighteen (one manager per value stream per shift multiplied by six production areas multiplied by three shifts).

Sample Size - The sample size selected for the focus group was six. This was consistent with sample sizes used by recent authors of the Repertory Grid Analysis technique (Bauman 2015). It was consistent with the range of three to sixteen mentioned by Pike & Kotsi (2016) and Smith et al. (1997) for typical Interpretative Phenomenological Analysis studies. Guest et al. (2006) arrived at similar conclusions that, in selecting purposive samples, they found that the basic meta-themes were revealed within six interviews.

The sample size was intended to be representative of the population of managers, i.e. a theoretically revealing sample that would unearth those constructs that were operating nominally in the environment within which the managers were working.

Sample Strategy - The sample strategy employed was to stratify the sample population according to their current production areas. In Figure 3-10 below I have shown all eighteen managers and the value streams that they worked in. I have referred to them as ‘manager’ to retain their anonymity, as requested by Automotive UK. The six selected managers for the focus group were taken from the first row highlighted in the table. The aim of this was to have at least one manager from each of the value streams. If for the purpose of saturation, further samples were necessary, the intention was to move to the second row and start again from column one.

	Value Stream						
	1	**2**	**3**	**5**	**4**	**6**	
Managers	Manager 1	Manager 2	Manager 3	Manager 4	Manager 5	Manager 6	Focus Group
	Manager 7	Manager 8	Manager 9	Manager 10	Manager 11	Manager 12	
	Manager 13	Manager 14	Manager 15	Manager 16	Manager 17	Manager 18	

Figure 3-10 – Sample Strategy for Repertory Grid Analysis – Elements & Constructs

This made the sample universe as diverse as possible within the case study, by ensuring a spread across all the different value streams. If it was found that this sample universe did not lead to saturation of constructs then enlarging the sample to include additional sites was considered possible (three other Automotive UK sites existed in the UK).

Source the Sample - Access to the participants was not problematic. The managers all worked on a rotating shift basis so some minor advanced scheduling was necessary.

With this focus group of six managers I used three different data collection methods. These were participant-led-photography, photo-elicitation and eliminate, combine, rearrange, simplify (ECRS). These methods were structured according to the first two steps of the Repertory Grid Analysis design; ‘elements’ and ‘constructs’, shown in Figure 3-8 above.

3.5.2 Data Collection Method One - Participant-Led-Photography

The first data collection method for this research was the use of participant-led-photography (Wang & Burris 1997), see Figure 3-11 below. This involved asking managers to take photographs of examples of shop-floor visual communication from within their own production areas (value streams).

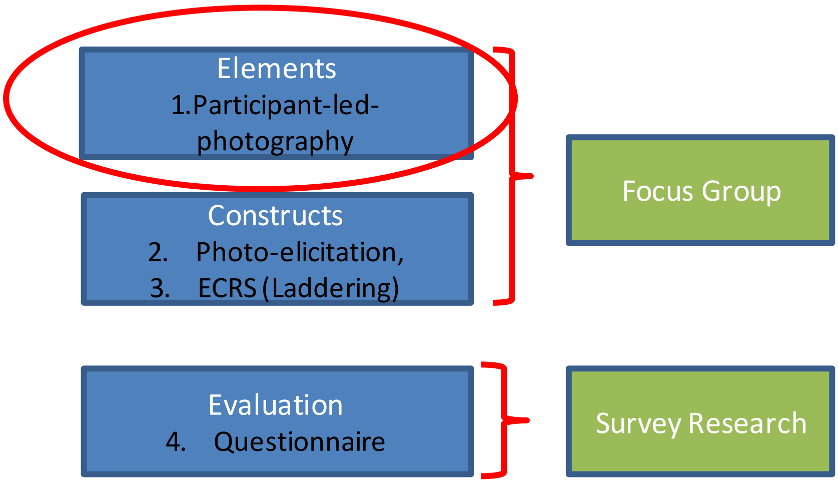


Figure 3-11 - Research Methods – Repertory Grid Design

Participant-led-photography is described by its originators, Wang & Burris (1997), as a process which allows participants to select photographs which they consider as reflecting their “…community’s needs and assets” (Wang & Burris 1997, p380).

The purpose of this first step was to capture a variety of photographs of shop-floor visual communication currently in use. These photographs were used as input data to the second step of the research. This next step was aimed to explore the ‘constructs’ that were ‘motivating’ the use of visual communication by giving the managers the opportunity to contextualise and codify the content of the photographs. It was therefore important to have sufficiently rich (diverse) examples of the different types of visual communication.

The elicitation was based on six photographs per value stream multiplied by six value streams, which resulted in 36 in total. This improved the likelihood of achieving the notion of saturation (Bauman 2015); capturing the key themes in the operating environment.

To ensure a good cross section of visual communication were photographed during this part of the data collection, I provided some guidance to the managers about the generic use of visual communication. This guidance was informed by the findings from the literature review. I utilised the list from the proposed taxonomy for visual communication by Greif (1991). This list was stated by Greif (1991) to represent the typical usage of visual communication within organisational shop-floors (see Figure 3-12 below).

Guidance Sheet – Participant-led-Photography

1. Identification of territory
2. Identification of equipment such as machines, tools and maintenance equipment
3. Identification of the team. Personnel associated with each cell or production line
4. Markings on the floor
5. Marking of tools and racks. Guidance for tool and product placement and identification
6. Technical area. Auxiliary documentation that gives support to the cell or line
7. Communication and rest areas, with information billboards
8. Display of cleaning elements and instructions for their use in the cell or line
9. Manufacturing instructions and technical procedures
10. Maintenance guidelines
11. Computer terminal
12. Production schedule
13. Maintenance schedule
14. Physical identification of raw materials, work in progress and finished product inventories
15. Monitoring signals for products and processes
16. Statistical process control (SPC)
17. Register of problems
18. Objectives, results and deviations
19. Visibility of improvement activities such as actions taken
20. Company mission and vision statements; quality, environment and safety policies

Figure 3-12 – Guidance for Participant-Led-Photography

(Greif 1991, p20-21)

The managers were issued with a compact digital camera with a point and shoot facility for capturing images. The photographs of visual communication were printed four to a page (A4) in black and white format. Figure 3-13 below shows an example of how the photographs were printed.

Figure 3-13 – A4 Printed Format of Participants Photographs

The use of black and white printing was intended to improve the research validity (Paltridge & Phakiti 2010) by catering for those that might have of Colour Vision Deficiency (CVD) often referred to as colour-blindness (Albany-Ward & Sobande 2015, Hasrod & Rubin 2015). However, my use of black and white images had the potential to create an alternative bias, as normally the shop-floor visual communication uses colour as a component part of the communication, i.e. the use of green/red status indicators. I considered the elimination of colour from the photographs to be the lesser of the two possible biases. The photographs were used as part of the structured interviews to elicit psychological constructs as well as being used during the survey phase of the research. In both these contexts the photographs were used as artefacts, as part of a projective technique (Bagnoli 2009), to enable the managers to interpret and articulate their experience of the shop-floor (Bell 2012, p4, referring to work by Oswick & Montgomery). I considered that using black and white photographs during all phases of the research would introduce less variability, as the managers were familiar with the visual communication and knew that normally it uses colour as a component of its meaning.

3.5.3 Data Collection Method Two – Photo-Elicitation

The second step of data collection was aimed to explore what manager's think are the reasons for using particular visual communication. For this step I used a data collection technique called photo-elicitation (Botterill & Crompton 1987), see Figure 3-14 below.

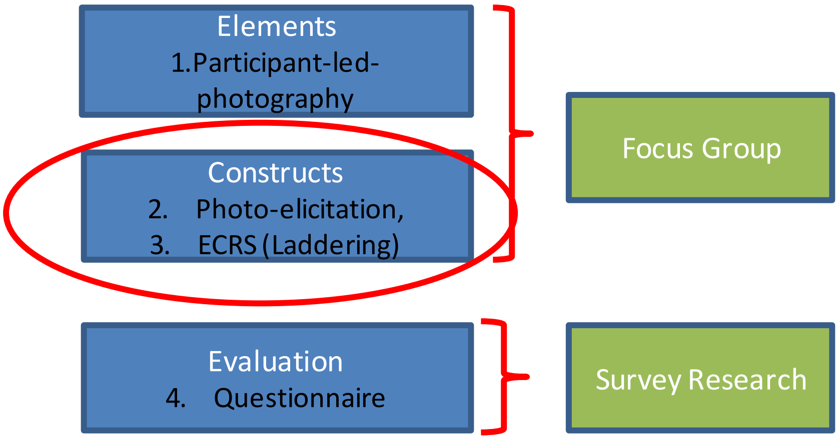


Figure 3-14 – Research Methods – Repertory Grid Analysis Design

The photographs collected by each manager using the first research method, participant-led-photography, were presented back to the same manager as part of a structured interview. They were then encouraged to speak about what they saw in those photographs. Classically within Repertory Grid designed research, these photographs are presented to the participants as triadic sets. The participants are asked to consider how any two photographs are similar to each other, yet different in some way from the third. The similarity between any two is intended to elicit one side of a construct, and the difference between these two and the remaining third element is intended to elicit the polar opposite of that same construct. This elicitation technique results in the generation of bi-polar constructs that make them suited for the creation of a questionnaire.

Various techniques have been suggested for the elicitation process within Repertory Grid Analysis design, with recognition that different approaches can result in different outcomes (Neimeyer et al. 2005, Hagans et al. 2000). Some of the options of how the elicitation process can be varied are included in the later discussion chapter relating to the methods employed. Kelly (1963), the inventor of the technique, himself suggested different ways in which the elements (photographs) could be presented. By alternatively suggesting dyads and triads, and proposing different ways in which they can be used by the researcher, he was acknowledging that the methodology for elicitation is not fixed.

Figure 3-15 below shows the number of triadic permutations for a full factorial approach (Burton & Nerlove 1976) for an increasing number of elements (photographs), based on a formula given by Pike (2007).

Elements	Triadic Sets
3	1
4	4
5	10
6	20
7	35
8	56
9	84
10	120
11	165
12	220
13	286
14	364
15	455

Figure 3-15 – Triadic Permutations of Photographs

(Table based on formula by Pike 2007)

In this research I asked each of the managers to capture twelve photographs of visual communication used in their production area that were meaningful to them. From these I selected six photographs from each manager for the purpose of photo-elicitation. The remaining six photographs from each of the participants (36 photographs altogether) provided the pool of photographs that were used later, within the survey phase of the research.

The six selected photographs from each participant were numbered on the back from one to six. These were then presented, three photographs at a time (triads), during the elicitation phase.

Below Figure 3-16 shows all the triadic combinations available with six photographs. Row one for example is interpreted as meaning that photograph number one, two and three would be presented as a triadic set. Row fifteen would mean that photographs numbered two, four and five would be presented as a triadic set.

Triad Nos	Photo Nos
1	1,2,3
2	1,2,4
3	1,2,6
4	1,2,5
5	1,3,5
6	1,4,5
7	1,4,6
8	1,5,6
9	1,3,6
10	1,3,4
11	2,3,4
12	2,3,5
13	2,3,6
14	2,5,6
15	2,4,5
16	2,4,6
17	3,4,6
18	3,4,5
19	3,5,6
20	4,5,6

Figure 3-16 - Triadic Sets of Elements for Photo-Elicitation

The above sequencing is consistent with what is called the Sequential Form method (Kelly 1963). This is where the triads are presented in a systematic way and where only one of the elements is changed each time they are presented.

The process of eliciting constructs was broken down into two steps. The first step was to ask participants to identify an elicited construct. This was recorded on a post-it note. The second step was to ask the participants to identify an opposite (or contrasting) emergent pole. This was recorded on a separate post-it note, thereby creating bi-polar (dichotomous) construct pairs. For this research I used the "contrast" method for capturing the emergent pole as opposed to the "difference" or "opposite" method (Neimeyer et al. 2005).

In order to keep the participants focussed towards the issue of visual communication during this process I used two scripted questions. These were:

- **Question one (elicited pole)** – "How, in relation to visual communication, are two of the photographs alike in some important way that distinguishes them?"
- **Question two (emergent pole)** – "To you, this distinguishing characteristic could be contrasted with a situation where...?"

3.5.4 Data Collection Method Three – ECRS

An approach was necessary to take the paired constructs from the above six different photo-elicitation interviews, and to reduce the various construct statements to a combined single unified consolidated list. This was so that the unique constructs that emerged from the six interviews could be identified and operationalised in the form of a survey. This third step is shown below in Figure 3-17 and is called ECRS (eliminate, combine, rearrange and simplify).

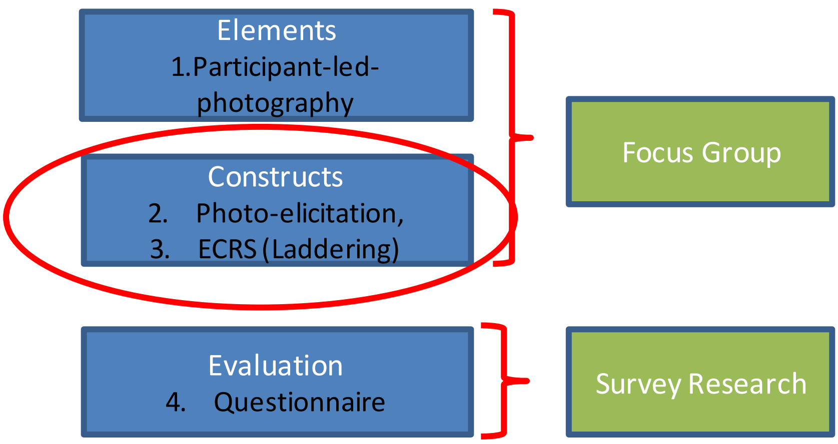


Figure 3-17 - Research Methods – Repertory Grid Design

Within Repertory Grid Analysis design, formal procedures such as researcher led coding are said to be unnecessary (Winter 2013) and various methods have been used, following elicitation interviews, to arrive at a list of consolidated constructs, i.e. frequency counts, content analysis, cluster analysis and principal-component analysis (a form of statistical analysis) (Pike 2007).

I have previously used a technique, which is normally attributed to 'time study' within industrial engineering, known as ECRS. This approach, reported in a 'Training Within Industry' bulletin (Training within Industry Service 1944), is more typically used as a method in relation to job analysis (work content) when analysing and redesigning manual activity in manufacturing environments. However, in my experience over several years, it has provided concise steps for individuals or groups to follow when consolidating and identifying themes within data.

I wanted to retain a strongly participatory aspect to the research so I arranged for the six managers to conduct their own individual consolidation of their elicited constructs, using the ECRS method. I saw this as a way of allowing the managers to consolidate their own constructs to unique themes without the risk of me, as an observer, making assumption about what they had elicited. This avoided the problem where the managers might have used similar words to each other but in fact were describing quite different constructs (Partington 2000).

The ECRS method was used individually with the managers to consolidate their elicited constructs to core themes as a form of self administered content analysis. Please note that during each of these steps described below the constructs comprise a pair; comprising the elicited construct on one posit-it note and the emergent construct on a second post-it note. The steps below explain how this was done in practice. The four steps of ECRS were as follows:

> "...**ELIMINATE** unnecessary details, **COMBINE** details when practical, **REARRANGE** for better sequence and **SIMPLIFY** all necessary details..."

(Training within Industry Service 1944, p3)

The first step was to '**Eliminate'**. Each of the managers organised their individual post-it notes into separate groups which in their opinion denoted separate themes. Any constructs that were considered duplicates were eliminated. This was done by simply sticking them together, one over the other. The purpose of retaining them was to ensure that at later stages of the process that they could be retrieved if there was a doubt about the way the process had been conducted.

The eliminate stage was followed by '**Combine'**. Here the paired post-its that had similar themes were combined together and where necessary they were re-written to more clearly express the ideas they were combining. Nothing was discarded, but the post-it notes were again stuck one over the other to retain traceability.

The next step was '**Rearrange'**. This step has similarities to a technique which is often used in conjunction with Repertory Grid Analysis called 'laddering' (Hinkle 1965). Laddering "...is based on the concept of ordination..." (Partington 2002, p226). The intention being to move from relatively concrete attributes identified in relation to some given elements (visual communication) to more "...abstract meanings of more pervasive existential importance" (Partington 2002, p226). In this research the purpose of this step was to prioritise the list of paired constructs and to arrange them in order - most to least important. The managers were asked to use a technique called 'paired comparisons method' (also known as the 'pair-wise comparison method') to prioritise the paired constructs. The use of this technique enabled a simple but systematic evaluation of each construct pair and allowed the individuals to prioritise them in order of those considered more concrete to those that were more abstract.

When conducting the laddering technique on individuals, Hinkle (1965) found that the hierarchy generated using laddering by the first participant was invariably repeated by the remaining group. As such, by utilising the paired comparisons method, the intention was to move towards a group consensus.

The last step was to '**Simplify'**. This step was intended to collapse the pairs of post-it notes that represent the poles of the construct into themes. The procedure I followed had similarities with several recent papers. Michie et al. (2005) developed a consensus framework relating to psychological theories. In that research a group approach was used to coalesce constructs to themes and these were then validated by comparing them to theoretical constructs. There are also similarities with the approach taken by Ab Aziz et al. (2015). They used a Repertory Grid Analysis design, including triadic elicitation and laddering. In this case a thematic analysis was used to consolidate participant’s feedback from interviews to key classification factors. Also in a recent study, Pike & Kotsi (2016) used the Repertory Grid Analysis design, where elicited responses were grouped into categories by the researchers by looking for similarities in the wording.

I did not intend to engage in a detailed analysis of the defined constructs in an attempt to demonstrate their statistical validity. Techniques such as 'Implication Grids' are available (Hinkle 1965). However there is an interesting rhetorical question proposed by Fransella & Bannister (1977) which is to ask what levels of statistical significance represents a psychological significance? They warn of “...the fascination of figures” stating that inferences taken from such grids are premised on a belief that statistical relationships in the grid represent some correlation between an individual’s psychological constructs. They argue that this may in fact remove us from what respondents actually told us or meant in respect of the relationships between the constructs.

There is also the added disadvantage of using ‘Implication Grids’ and construct checking techniques in that they often require more information to be collected during the elicitation interview and therefore significantly increase the amount of contact time required with respondents (Korenini 2014). In the practical setting of a manufacturing shop-floor I needed to remain sensitive to the amount of time I was requesting of the managers away from their normal production duties.

Participant-led-photography, photo-elicitation and ECRS were the first three steps and completed the first phase of this research. The second stage of research was based on survey methods and this is discussed next.

3.5.5 Survey Methods

Having described the first of the key methods used in this research, i.e. focus groups, and the associated data collection methods, I will now explain the second key method, i.e. survey methods.

This part of the research was structured according to the ‘evaluation’ stage of the Repertory Grid Analysis design shown in Figure 3-18 below. This specifically involved the use of an administered questionnaire (Dillman 2007) for data collection.

Surveys are typically designed to measure particular characteristics of a population through the use of questionnaires, interviews and/or observations (Gray 2004). The survey phase of this research was to enable observations about the population of managers and operators by taking a representative sample from that group and conducting data gathering through an administered questionnaire (Saunders et al. 2012).

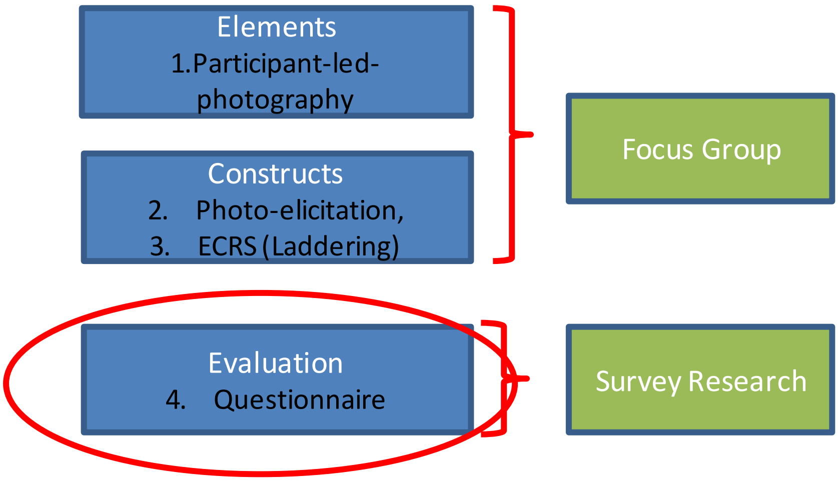


Figure 3-18 - Research Methods – Repertory Grid Design

During this phase of the research a questionnaire was created from the consolidated constructs (resulting from the ECRS steps). A benefit of the photo-elicitation method used in the way described above is the ‘dimensionality’ (Pike 2007) of the participant created constructs that allows them to be used to both categorise (construct-wise) and discriminate between (rating wise) the objects (visual communication) being considered. This feature of photo-elicitation, in the context of a Repertory Grid Analysis design effectively allows it to be used to create a questionnaire. How this was practically done will be shown by way of an example later in this chapter.

Data Collection Method Four - Questionnaire

The survey phase of this research was to enable data to be collected from both the managers and operators, by taking a representative sample from those groups and conducting data gathering through an administered questionnaire (Saunders et al. 2012, Gray 2004).

This was the culmination of the data gathering effort as the results of this questionnaire enabled correlation data to be established between the intended and interpreted meanings of a number of examples of visual communication.

Highlighted in Figure 3-19 below are shown the twelve managers (manager number from seven to eighteen) and the eighteen operators that formed the population that were surveyed. Note that an equal number were selected from each of the value streams.

	Value Stream					
	1	2	3	5	4	6
Managers	Manager 1	Manager 2	Manager 3	Manager 4	Manager 5	Manager 6
	Manager 7	Manager 8	Manager 9	Manager 10	Manager 11	Manager 12
	Manager 13	Manager 14	Manager 15	Manager 16	Manager 17	Manager 18
Operators	Operator 1	Operator 2	Operator 3	Operator 4	Operator 5	Operator 6
	Operator 7	Operator 8	Operator 9	Operator 10	Operator 11	Operator 12
	Operator 13	Operator 14	Operator 15	Operator 16	Operator 17	Operator 18

Focus Group

Survey Research

Figure 3-19 – Sample Strategy - Survey

The same questionnaire was to be administered to both managers and operators, and in this respect the choices about scale points (Dillman 2007, Partington 2002), mid-points and labelling (Krosnick & Fabrigar 1997) was a constant factor for both. I elected to use a five point Likert scale for the constructs. This scale was selected in consideration of using an exact match contingency table (Agresti 2010) analysis to determine the correlation rating.

I conducted administered questionnaires (Dillman 2007) with each of the thirty respondents. This was to ensure the maximum possible opportunity to gather fully completed questionnaires. The added benefit of this was that it allowed me to deal with administrative issues and ensure that all information was filled in on each questionnaire sheet.

3.6 Research Data Collection

Having described the data collection methods above, in this next section I have provided an account of actually using them for conducting the research. I have provided these details to enable the reader to understand the way in which each step is important for the subsequent step of this design.

Prior to conducting this phase of data gathering I held a meeting with the Human Resources (HR) Manager to ensure a communication was sent out to the managers to facilitate cooperation with this research study. This was important, as it showed that it was being sponsored by the senior level management (Symon & Cassell 2012).

3.6.1 Elements

Participant-led-photography - The ‘elements’ were a number of photographs, capturing examples of visual communication usage from the shop-floor, using the participant-led-photography technique.

I issued digital cameras and collected photographs from each of the six managers identified earlier who would participate in the participant-led-photography. I also issued each manager with the bullet point list showing the twenty elements for visual management identified by Greif (1991) shown earlier in Figure 3-12. No problems were reported and the photographs that were returned all gave me confidence the instructions had been clearly understood. Appendix H shows the photographs taken by each of the managers for the purpose of the next stage of the research, i.e. photo-elicitation.

Shown below are examples of the twelve images that were captured by the manager from value stream number one (see Figure 3-20). Please note that the images have been minimally obscured to remove the company name and logo as requested by Automotive UK.

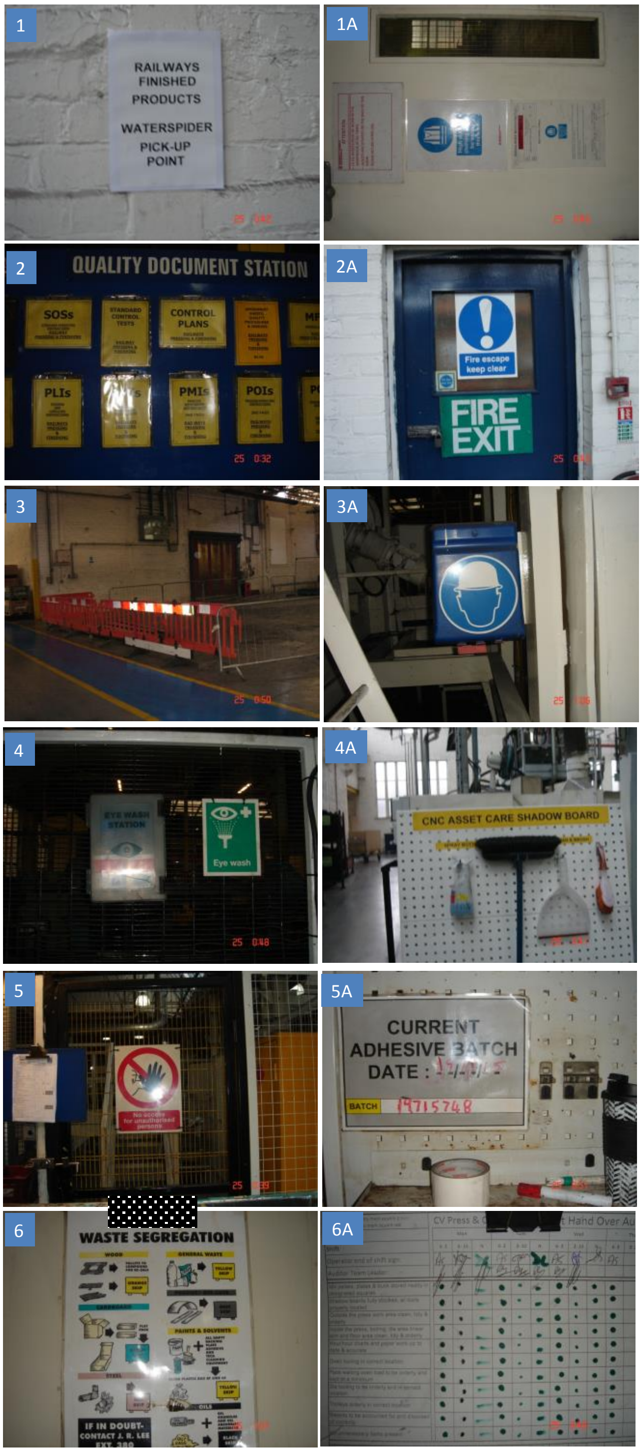


Figure 3-20 – Participant-Led-Photography – Examples of Photographs

Each of the 12 photographs was numbered in the order that they had been captured. All the odd number photographs as one, two, three, four, five, six and all even number photographs as 1A, 2A, 3A, 4A, 5A, 6A. These are indicated in the above figure on the front of the photographs (top left of each photograph). However, in practice the numbering was handwritten on the back of each photograph to avoid obscuring any details. Please see appendix A which shows a table of the numbering sequence.

3.6.2 <u>Constructs</u>

The next step was to use photo-elicitation to capture from each manager his psychological constructs in relation to the photographs that he had taken from his production area.

I met with each of the managers to conduct the photo-elicitation interview. During the photo-elicitation interview A6 sized photographs were used. Having explained the need to use black and white photographs (to avoid potential bias due to colour blindness) their use was accepted. I placed the six photographs, marked one to six on the back, face down on the table. Then referring to the triadic set combination table, discussed earlier (see Figure 3-15) I revealed three photographs at a time. I then asked the following question:

Question one - "How in relation to visual communication are two of the photographs alike in some important way that distinguishes them?"

Once the manager had identified which two photographs (of the three photographs presented) had something in common, I removed the third photograph to ensure that this would not create any distraction. The comment then made by the manager to explain what was distinguishing about the two photographs was recorded on a post-it note as the elicited construct. I then moved to question two and recorded the managers' response to the question:

Question two - "To you this distinguishing characteristic could be contrasted with a situation where...?"

This comment was recorded on a different coloured post-it note. The use of the post-it notes made it convenient to collect the elicited and emergent poles during the interview. It also acted as a visual cue to the interviewee to identify when we had completed one step and moved on to the next. I placed the post-it notes down on the desk away from myself to indicate that we were now moving on. Also removing the photographs and turning them back face down on the table made it clear that we had now moved to the next triadic set of photographs. To an extent this enabled the speed of the interview to be controlled.

Shown below (Figure 3-21) is an example of the way in which the elicited and emergent constructs were captured during the interviews, using post-it notes. Please note that in addition I also collected supplementary comments that were made by the interviewee on separate post-it notes. Appendix I shows the original post-it note results of the photo-elicitation for each of the managers.

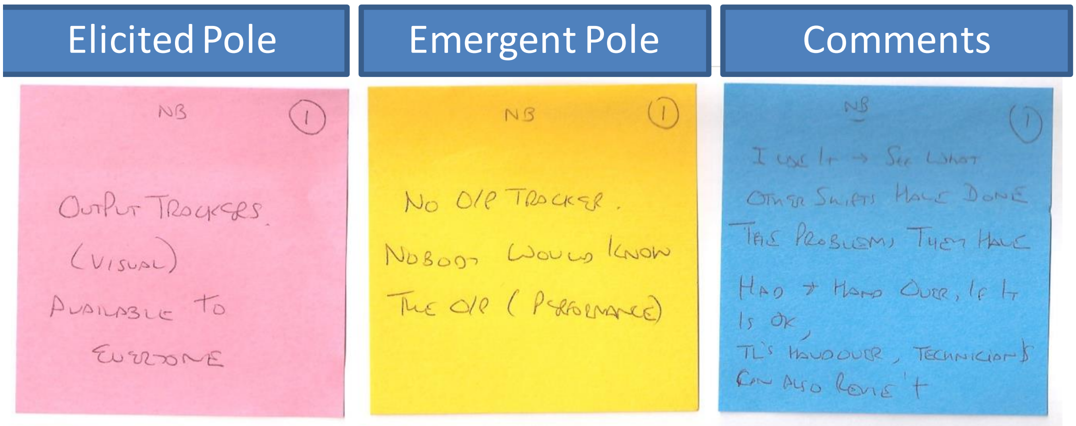


Figure 3-21

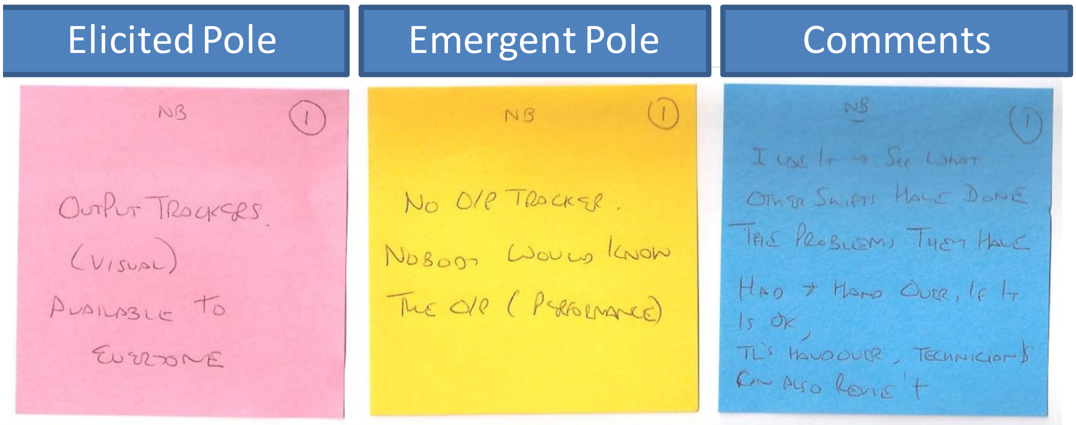


Figure 3-21 – Example of Elicited & Emergent Pole Comments

The use of full factorial permutations for the triadic sets meant that, as predicted (Kelly reported by Pike 2007), there was a feeling that saturation of the constructs was reached before all the twenty permutations had been presented. After around ten triadic sets the managers would often comment that "I think we've had these pictures before" or "same comment as before". I felt it important to go through all twenty permutations to ensure saturation of constructs as these would be used to create the questionnaire themes. I decided that as the first interview progressed that I would continue with presenting all twenty permutations during the remaining five interviews. However, I would explain beforehand to the participants that repetition, whilst likely, was a necessary part of the methodology. This was to ensure that we had exhausted all possible constructs arising from the photographs.

The interviews took around one hour each. I considered this an acceptable interview duration despite some possible frustration of repetition. As an example, the results of an interview with one of the managers is summarised in Figure 3-22 below.

The first column identifies that this interview was conducted with the manager from value stream number one. The second column shows the triadic set sequence number, i.e. the sequence number identifying the combination of photographs used for the elicitation activity (shown earlier in Figure 3-16). The following three columns show verbatim the comments from the photo-elicitation activity in respect of the elicited and emergent constructs. I have shown here a final column for ancillary comments captured during the interview.

Value Stream	Photo-Elicitation				
	Triadic Nos	Photos. Nos.	Elicited Constructs	Emergent Constructs	Ancillary Comments
1	5	1,3,5	Both area made safe. H&S - Don't go in this area.	Potential accident if you go inside	One is closed area. One is open area.
	6	1,4,5	As before	As Before	
	17	3,4,6	Safety related	Unsafe areas	One is a caged area. Other is open plan area.
	20	4,5,6	Closed area. Direct instruction for safety	Potential accident	Bent guarding. Using a pokey stick. Must be a solution.
	19	3,5,6	Closed area. H&S. (Will have an accident)	Open Area. H&S. (Potential for an accident)	One is electronic & one is manual.
	18	3,4,5	Enclosed area with potential Hazard	Accident - Potential risk	
	15	2,4,5	Safety - Stopping unsafe acts	Operator able to injure themselves.	Both are H&S related.
	16	2,4,6	Essential for running the cell	Quality defects going to customer. Environmental issues.	Waste disposal & quality of production
	13	2,3,6	Required to work effectively in the cell	Lack of control in the cell. Not enough instructions	Some are controlled documents by others areas and others are from within this area.
	10	1,3,4	H&S Photo	Having an accident	
	14	2,5,6	Direct instructions relating to H&S	Safety or environmental problem	Caged area. One is open instruction for everyone
	11	2,3,4	Visual indicators of risks in those areas	Potential accident	On the barrels it does not really tell you the risk - area just cordoned off
	12	2,3,5	No access allowed warning - barrier	Not safe conditions. People have access not safe.	Both related to safety. One is electronic. One is manual.
	3	1,2,6	Op instruction inside the cell perimeter	Instruction for someone outside the cell	Cell perimeter thinking inside/outside cell
	1	1,2,3	Assisting you in your job	Telling you not to do something 'no entry'	Telling you do to something specific. 2nd telling someone else to do the job.
	8	1,5,6	Both necessary to run consistent to FMOS	Missing deadlines. Not complying with environmental waste disposal	
	9	1,3,6	Impacts the boundary of the cell perimeter	Possible missed order for customer	Pick-up point at one end of the flow. Barriers preventing the train from working in a circular path.
	4	1,2,5	Effect control of cell. External & Internal	Missing customer deadlines. Products not being taken away.	Outside of control of leaders
	2	1,2,4	Instruction to you to do something	No instruction for operators about material or safety	Traffic lights indicating if the job has been done. Part of the TL role is to check eye wash station
	7	1,4,6	Instruction to op / water spider. H&S / Production	Contamination malfunction FMOS	Ones production instruction. One is environmental segregation

Figure 3-22 – Manager Number One - Constructs

The next step was the use of the ECRS technique.

Eliminate, Combine, Rearrange, Simplify (ECRS) – This step was to use the ECRS technique to take the above elicited constructs, shown in the above table as the elicited and emergent columns, and to consolidate these to a single list of themes that would be suited to create a questionnaire.

All six managers were invited to a meeting room to go through the ECRS process. However, they were asked to work as individuals for completing these steps.

I placed the post-it notes arising from the elicitation interviews on sheets of flip chart paper and introduced the ECRS method steps to the managers to enable them to consolidate their own elicited constructs to key themes.

For ‘eliminate’, each manager considered each of their pairs of constructs in turn to identify any that were clearly duplicates. In conducting this exercise I requested that any pair of constructs that were considered to be the same as another must be stuck over the top of each respective identical post-it, e.g. a corresponding elicited post-it note could only be stuck over another elicited post-it that was considered to be identical. From past experience the retaining of post-its by sticking them together ensured that it would be easy to track back to understand how the consolidation activity had been conducted.

For ‘combine’ I asked each manager to take any pair of constructs that were similar enough to another pair and to combine them. This meant that if a statement from one set of post-its was considered comparable and encompassing enough to another set, then the more encompassing one should be stuck over the top of the first set.

In fact all the managers conducted both eliminate and combine steps together. This was not surprising and replicated past experience when using this technique. Individuals have typically identified identical and similar themes as they work through the post-it note comments and prefer not to be restricted too much in how they go about this consolidating process. I therefore did not insist on a strict following of each step in turn.

The next step was to ask the managers to prioritise their remaining pairs of constructs, i.e. ‘rearrange’, using the paired comparison method mentioned earlier.

The final step was to ask the managers to ‘simplify’ the wording such that it captured the essential elements of the theme it represented. Having the post-it notes stuck one over the other from the previous steps proved useful as the managers could easily flick through these and arrive at statements that, in their opinion, captured the essential key theme/s.

Looking at the themes generated, I was satisfied with the results and felt confident these would be suited to creating a questionnaire. The result of the photo-elicitation and ECRS interview with one of the managers is shown in Figure 3-23 below. The post-it note at the top shows the theme that the manager identified as encapsulating the post-it notes below it. This example shows four constructs, emerging from the photo-elicitation, which have been consolidated to a single theme after the ECRS activity.

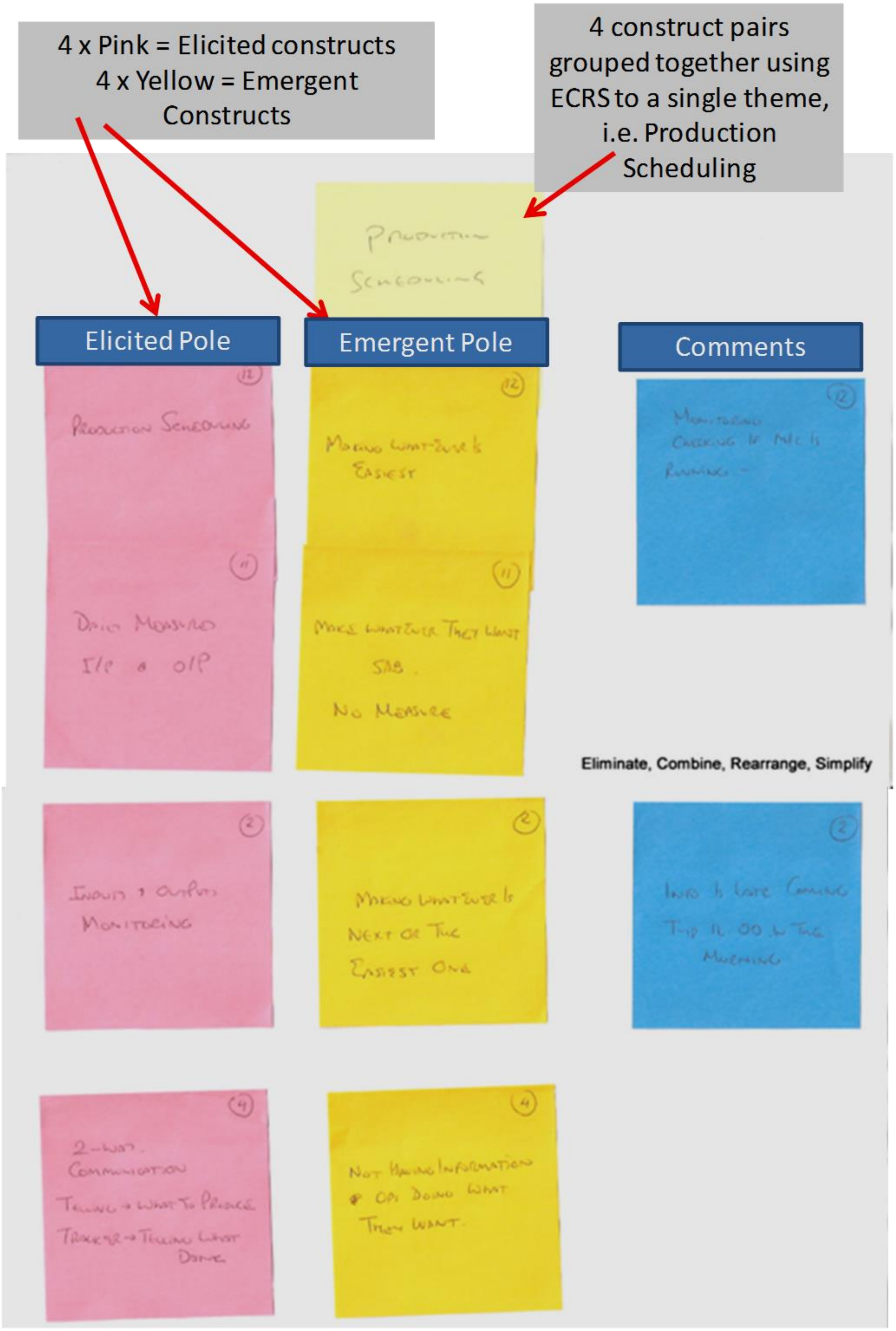


Figure 3-23- Manager Number One - Constructs and ECRS Activity

I have presented below an example of the elicited and emergent constructs and the resulting themes in the form of a table, see Figure 3-24 below. The first six columns are repeated from above table (Figure 3-22). The final section, under the column heading “ECRS”, shows the consolidated themes that emerged from the managers ECRS activity.

In total the steps of ECRS took around thirty minutes. This was made easier as there was minimal rewriting and generally only required the managers to sort through the post-it notes that had been generated during the photo-elicitation interviews.

Value Stream	Photo-Elicitation					ECRS
	Triadic Nos	Photos. Nos.	Elicited Constructs	Emergent Constructs	Ancillary Comments	Theme
1	5	1,3,5	Both area made safe. H&S - Don't go in this area.	Potential accident if you go inside	One is closed area. One is open area.	Awareness in Area
	6	1,4,5	As before	As Before		
	17	3,4,6	Safety related	Unsafe areas	One is a caged area. Other is open plan area.	
	20	4,5,6	Closed area. Direct instruction for safety	Potential accident	Bent guarding. Using a pokey stick. Must be a solution.	Visual & Verbal
	19	3,5,6	Closed area. H&S. (Will have an accident)	Open Area. H&S. (Potential for an accident)	One is electronic & one is manual.	
	18	3,4,5	Enclosed area with potential Hazard	Accident - Potential risk		
	15	2,4,5	Safety - Stopping unsafe acts	Operator able to injure themselves.	Both are H&S related.	Injury Awareness
	16	2,4,6	Essential for running the cell	Quality defects going to customer. Environmental issues.	Waste disposal & quality of production	Quality
	13	2,3,6	Required to work effectively in the cell	Lack of control in the cell. Not enough instructions	Some are controlled documents by others areas and others are from within this area.	Visual & Verbal Communication
	10	1,3,4	H&S Photo	Having an accident		Be Alert in Area
	14	2,5,6	Direct instructions relating to H&S	Safety or environmental problem	Caged area. One is open instruction for everyone	
	11	2,3,4	Visual indicators of risks in those areas	Potential accident	On the barrels it does not really tell you the risk - area just cordoned off	Stop - Do Not Enter
	12	2,3,5	No access allowed warning - barrier	Not safe conditions. People have access not safe.	Both related to safety. One is electronic. One is manual.	
	3	1,2,6	Op instruction inside the cell perimeter	Instruction for someone outside the cell	Cell perimeter thinking inside/outside cell	Follow Cell Procedure
	1	1,2,3	Assisting you in your job	Telling you not to do something 'no entry'	Telling you do to something specific. 2nd telling someone else to do the job.	
	8	1,5,6	Both necessary to run consistent to FMOS	Missing deadlines. Not complying with environmental waste disposal		
	9	1,3,6	Impacts the boundary of the cell perimeter	Possible missed order for customer	Pick-up point at one end of the flow. Barriers preventing the train from working in a circular path.	
	4	1,2,5	Effect control of cell. External & Internal	Missing customer deadlines. Products not being taken away.	Outside of control of leaders	Measure the Product
	2	1,2,4	Instruction to you to do something	No instruction for operators about material or safety	Traffic lights indicating if the job has been done. Part of the TL role is to check eye wash station	Traffic Movement
	7	1,4,6	Instruction to op / water spider. H&S / Production	Contamination malfunction FMOS	Ones production instruction. One is environmental segregation	

Figure 3-24 – Emergent Themes to Questionnaire Poles

Appendix J shows the results of the ECRS session with the six managers. The appendix shows the original post-it notes recorded from the photo-elicitation interviews as well as the results of the ECRS method.

Evaluation - The next step was to use these themes identified by the managers to create a questionnaire. The intention was to use the original wording with minimal modification to retain the 'voice of the managers' as much as possible. This was straightforward due to the way in which the themes had been summarised in the ECRS steps. In Figure 3-25 below is an example of how the themes that emerged from the participant-led-photography, photo-elicitation and ECRS activity were adjusted to arrive at wording that was suited for the questionnaire. Dillman (2007) recommended the use of as few words, containing as few letters each, as possible, but still to use complete sentences to avoid "erroneous" answers. In the figure below, the selected wording is shown in the columns headed 'questionnaire - left hand pole' and 'questionnaire – right hand pole'. Also shown is a column referred to as common stimulus. This is the identification of keywords (bullet points) which would appear as an introduction to each of the question to orientate those filling in the questionnaire.

Identifies the manager / value stream

'Theme' shows the consolidated themes that I considered unique that emerged from the ECRS activity

The common stimulus is a short phrase to orientate the respondents of the questionnaire.

Pole labels used in the questionnaire

	ECRS		**Questionnaire Design**		
Manager	**Theme**	**Unique Construct**	**Common Stimulus**	**Left Hand Pole**	**Right Hand Pole**
4	Communication Throughout	1	Communication	**Strong focus on Information / Feedback for Operators**	**Weak focus on Information / Feedback for Operators**
	Dusty & Dirty	2	5S	**Strong focus on Cleanliness & Tidiness**	**Weak focus on Cleanliness & Tidiness**

Figure 3-25 – Conversion of Themes to Questionnaire Poles

The next step was to design a questionnaire layout with sufficient "...visual navigational guides and use them in a consistent way to get respondents to follow the prescribed navigational path and correctly interpret the written information" (Dillman 2007, p105). As discussed before, I opted for a five point Likert scale with the end points labelled, and an "N/A" option. I did not feel the need for too much detailed explanation to be printed on the questionnaire because I had planned to administer the questionnaire to ensure it was completed in the correct way. However I still wanted to design a questionnaire that was easy to follow without my intervention, and one that looked professional.

In Figure 3-26 below I have shown an example of how two of the ten questions were presented in the final questionnaire. The use of shading was to draw the attention of the person answering the questionnaire towards the answer boxes (Dillman 2007). The common stimulus keywords can be seen along the left of the questionnaire sheet. These were included to orientate the respondents to the question themes (Dillman 2007).

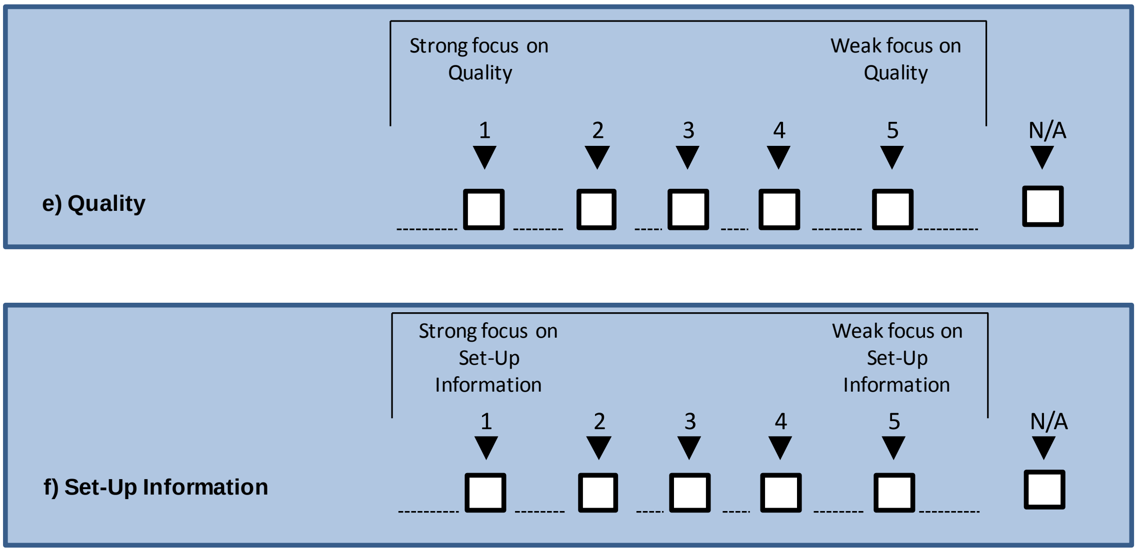


Figure 3-26 – Examples of Questions Format

With a text sizing that I considered suitable from an ease of reading point of view the final result was a double sided A4 questionnaire design, orientated in portrait format. Copies of the questionnaire sheets are shown in Appendix L.

Questionnaire Administration - I administered the questionnaire according to my research design. In each of the six value streams there was a manager's office located within, or adjacent to, the perimeter of each respective production area. I used these offices to conduct the interviews with both the managers and operators.

I provided the respondents with blank copies of the questionnaire and explained that I would provide them with one photograph at a time (ten in total). I clarified that there was no right or wrong answer but only their opinion about what they saw.

I ensured that the photograph number was correctly entered to the respective sheet and also observed to ensure that all questions were answered. At the completion of each sheet, I removed both the photograph and questionnaire from the manager/operator and presented the next photograph.

The process of rating all ten photographs took around 30-45 minutes each. It was clear that once one or two photographs had been rated that the respondents became more familiar with the design of the questionnaire and that progress became more rapid.

Questionnaire / Evaluation (Data Analysis) - The decision to have stratified value stream by value stream data was to ensure a comparison could be made between value streams. This was to establish in what ways the visual communication differed and what could be established from these differences.

The data collected was arranged (by value stream) in the form of contingency tables. Analysing the data using an exact match approach provided a practical and easily replicated method of deriving the effectiveness measure for specific visual communication. This approach treated the construct scale as having nominal values, i.e. discrete variables with unordered categories (Powers & Xie 2008). The choice of using a five point Likert scale plus ‘N/A’ option (effectively a six point scale) was in consideration of this analysis method. Having a greater number of continuum divisions potentially would have reduced the number of exact matches and may have driven the analysis towards using more complex statistical approaches.

Summary from Data Gathering

Overall I was satisfied with the research methodology in respect of creating the questionnaire and its subsequent administration. Some of the learning points were:

Meeting with Human Resources and Communication - It was important to get permission prior to conducting this research. In part this was due to the time commitments required from managers and operators. It was also my intention to subsequently utilise the findings to make improvements in the organisation. Importantly, this meeting ensured the research was communicated to the individuals from their own senior managers and demonstrated hierarchical sponsorship (Symon & Cassell 2012).

Photographs - The use of cameras on the shop-floor by the managers, and agreement that the images would not be distributed outside the company, avoided any conflicts with the current company policy. This policy prohibits the use of cameras on the shop-floor by third parties.

The pre-defined selection process for selecting which images to use for the photo-elicitation and which were to be rated using the questionnaire proved to be easy to administer.

Visual Management Elements - Crib sheet - The issuing of the crib sheet comprising the twenty elements for visual management identified by Greif (1991), shown in Figure 3–12, provided sufficient guidance to the managers without confusion or the need for further instruction. However the implications of using this crib sheet will be considered in the discussion chapter.

Triadic Sets Permutation - I do not think in the case of this research that the full factorial triadic elicitation created too much frustration, but there was quite a lot of time demanded with the managers for the photo-elicitation step. If it is possible to reduce this time through the use of smart methods designs, i.e. partial factorial triadic elicitation designs, I consider it worth investigation in the future.

Questionnaire Administration - I was satisfied that the one-to-one administration of the questionnaire was the right choice. It ensured a 100% response rate and that all questionnaires were correctly filled-in. It also provided the opportunity to collect additional soft data in terms of comments and observations.

Post-it Notes - Although seemingly an insignificant point, I consider the use of post-it notes helpful to ensure a smooth progress from step to step without the need for significant rewriting. Once the comments had been recorded during the photo-elicitation phase then the same post-it notes could be applied to the ECRS stage. The use of the post-it notes supported my intention to retain a participatory nature by giving them back to the managers and allowing them to manipulate them personally.

Prior to conducting the above data gathering activity, I conducted a pilot study to test the methods and to explore any changes that might be necessary in light of experience. I have summarised this briefly in this next section.

3.7 Learning from Pilot Study

I felt that a pilot study was worthwhile and would potentially highlight issues that could be addressed prior to the main research study. This pilot was conducted within the value stream that had the additional hierarchical (supervisory) level mentioned earlier, and shown on the diagram relating to organisation structure (Figure 3-7). I did not want to conduct the pilot study with any of the 18 managers as they were all contributing to this research and I did not want any one of them to become familiar with the research methods compared to their colleagues.

The key learning points from the pilot study were;

Questionnaire format - In the pilot study questionnaire I used a landscape format. This was possible because the photo-elicitation and subsequent ECRS activity revealed only five constructs, which in turn resulted in only five questions on the questionnaire. However, I realised that there were some issues. The limited space of this format meant that pole labels were poorly aligned with the boxes they represented. In the pilot study this did not lead to confusion as the questionnaire was being administered and I was able to explain which labels represented the construct poles, but I was not satisfied with this design, and decided to use a portrait format for the main research.

Additional Notes - During both the photo-elicitation and questionnaire administration I found that additional comments were made by the supervisor which I had not recorded. I realised afterwards that these soft comments could inform the thinking about the emergent themes. During the main research this led me to record these comments using an additional, different coloured, post-it note and to post them along with the bi-polar constructs during the elicitation phase. In this way it would be recorded and remain visible and possibly useful.

Questionnaire Administration - I originally planned to administer the questionnaire in a group setting. However having completed the pilot study, I considered it would be more effective to conduct this part of the research on a one to one basis. The potential benefits were:

- From a data accuracy perspective it meant that I was be able to ensure the respondents name and the value stream section they worked for were correctly recorded, so I did not lose data traceability.
- I was able to ensure the completed questionnaires clearly recorded which photograph was being rated.
- I was able to answer directly any questions the participants had.
- I could observe them filling in the questionnaire and could learn about how different participants approached this.
- I had the chance to check the questionnaire sheet they had just completed whilst they started to fill in the next one.
- It was a practical way to ensure that soft data could be collected. By sitting opposite the participant I was able to directly record any comments they made. In a group setting, many of the comments would have been easily lost.
- It treated both managers and operators in an equitable way. Both parties had one to one sessions which were focussed on capturing their thoughts about the same visual communication using the same questionnaire.

The above points were minor adjustments but ensured an overall smooth data collection phase for this research.

3.8 Summary

The aim of this research was to measure the correlation between the intended and interpreted meaning of visual communication. In my literature review I found there was limited research relating to the use of visual communication in organisational settings, although there was relatively more about the use of visual methods for conducting research itself (Margolis & Pauwels 2011). I did not find precedents about how to research this topic but came across ideas from research in tourism (destination images) and the use of visual methods to enhance the participatory nature of research. These two areas strongly informed my choices about how to approach the research aim and objective.

Accessing the intention of managers and the interpretation of operators in the context of visual communication led me to consider that my preferred research approach of neo-positivism was compatible with my research objectives. Visual communication takes place in a social context (Jappy 2013, Kress & Van Leeuwen 2006) and my proposed use of a neo-positivistic approach was consistent with accessing the correlation between intended and interpreted meanings.

The overall methodology I selected was a holistic single case research study using an embedded approach (Yin 2009). Based on the Shannon & Weaver (1949) Communication Model as a theoretical base, I used the Repertory Grid Analysis design to structure this research. This comprised three parts; elements, constructs and evaluation. This design was put into practice using four data collection and consolidation methods; participant-led-photography, photo-elicitation, ECRS, and a questionnaire. I opted to conduct a pilot study of the above design and methods to learn about their compatibility. This provided an opportunity for practice before conducting the main data gathering phase of the research.

In the next chapter I have presented the findings from the research and considered how these answer my research aim. Then in chapter five I have looked at the implications of these findings in respect of the literature and the research methods I have employed.

4 Findings

In this chapter I have presented the findings from the research methods, showing how each step builds on the results of the preceding step, finally resulting in a measurement of the intended and interpreted meaning of a number of visual communication from Automotive UK.

In the first section of this chapter I have presented, for each of the six managers, the photographs they captured using the participant-led-photography method, the elicited constructs using the photo-elicitation method, and the themes, having condensed these using the eliminate, combine, rearrange, simplify (ECRS) methodology. It was these consolidated themes that were operationalised in the form of a questionnaire to enable visual communication to be measured.

In section two I have compared the results of the questionnaire which was administered to the managers and operators. This section has been structured by presenting each of the ten photographs alongside the exact match contingency tables used to assess the correlation of visual communication. In some instances it has been necessary to look at the contingency table data at the level of individual themes or value streams, to explore behind the top level correlation rating. I have also explained the Fisher exact test which has been used to ensure that the survey data shows a correlation that cannot be explained by simply by chance alone.

In the last part of this chapter, I have briefly highlighted some interesting tentative findings from the pilot study. The pilot study was conducted only to test the research methods for their practicality within the case study setting. In hindsight, having completed the main research, it became apparent that there was an interesting contrast between the themes that emerged from the supervisor and those of the managers. In this third section I have compared these two sets of themes (supervisor and managers) with each other as well as with the Jaca et al. (2014), and Greif (1991) taxonomy models. Comparing the themes with each other was based on my interest to know if the inference by Jaques (1990) was correct. He argued that the needs from, and contribution to, communication were different depending on different levels of the hierarchy.

4.1 The Psychological Constructs of Managers

The first of the research objectives was to elicit psychological constructs from the managers at Automotive UK who author the visual communication utilised on the shop-floor. These psychological constructs are said to be the rules or judgements that people use to navigate the world (Fransella & Bannister 1977). Consistent with the conceptual model, these constructs, elicited in response to examples of visual communication, are the perceived motivation for the use of visual communication from the perspective of the managers.

The methods that were used to enable access to these psychological constructs were the first two steps of the Repertory Grid Analysis design, i.e. elements and constructs. In Figure 4-1 below I have shown these two steps and highlighted the methods that were used to achieve this objective, i.e. participant-led-photography, photo-elicitation, and ECRS.

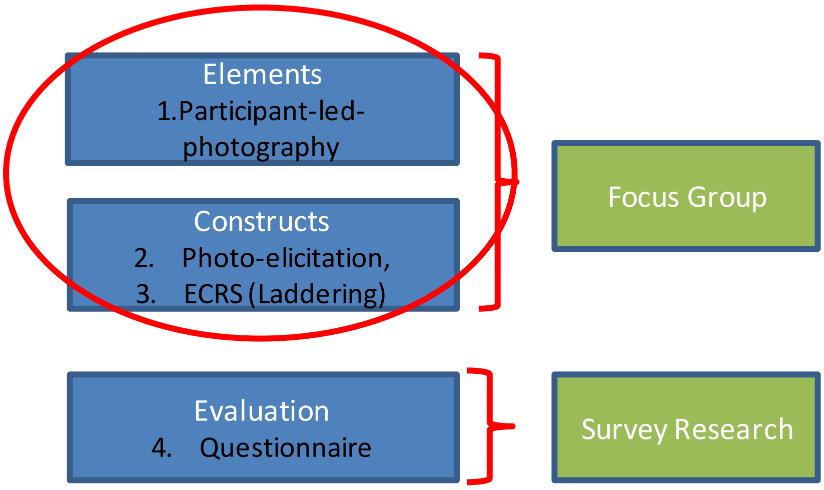


Figure 4-1 – Research Methods – Repertory Grid Design

In the next part of this chapter I have presented the findings from the six managers. These managers were each responsible for different shop-floor production areas (value streams). I have briefly explained some key aspects of each value stream to provide some context to the findings.

Each of the managers was asked to take twelve photographs during the participant-led-photography stage. Of these, six were used for photo-elicitation, and the remaining six were pooled together for the questionnaire phase of the research. In this section, for the photographs used for the photo-elicitation, I have identified some of the key features seen within them to enable the reader to better understand the themes that have emerged. I have also presented the six unused photographs from each of the managers and considered if these further reinforced, or alternatively, contradicted the elicited themes.

Please note that at this stage the intention is only to present the constructs (themes) that managers are using in relation to their use of visual communication. The measurement and interpretation of the intended and interpreted meaning of specific visual communication becomes possible once these themes have been operationalised and will be presented later in section two of this chapter.

4.1.1 Manager Nos. One – Heavy Duty Railway Applications

The Value Stream - This production area produced relatively large and heavy products, designed for railway applications. The comparatively low level of automation in this area meant that these heavy components were manually handled when loading and unloading the machine tools. Also these products were produced in comparatively small batch sizes which required the regular swapping of tooling between one product type and another. This tooling, which was manually changed over by the operators, was heavy and labour intensive to manipulate. This created a need for vigilance in terms of safety risks for the operators.

The Photographs - (Figure 4-2). The manager in this area captured three photographs that were safety related visual communication. One photograph was of a temporary barrier erected to indicate to operators an area undergoing refurbishment. The other two photographs were of safety signs attached to the perimeter guarding of machines which warned operators of safety risks. Of the remaining three photographs, one was of the company's policies regarding waste segregation to enable recycling, another showed a number of document holders relating to quality standards, and the final photograph showed a sign that designated a location where finished products were located to indicate they were now ready to be transported to the finished goods shipment area.

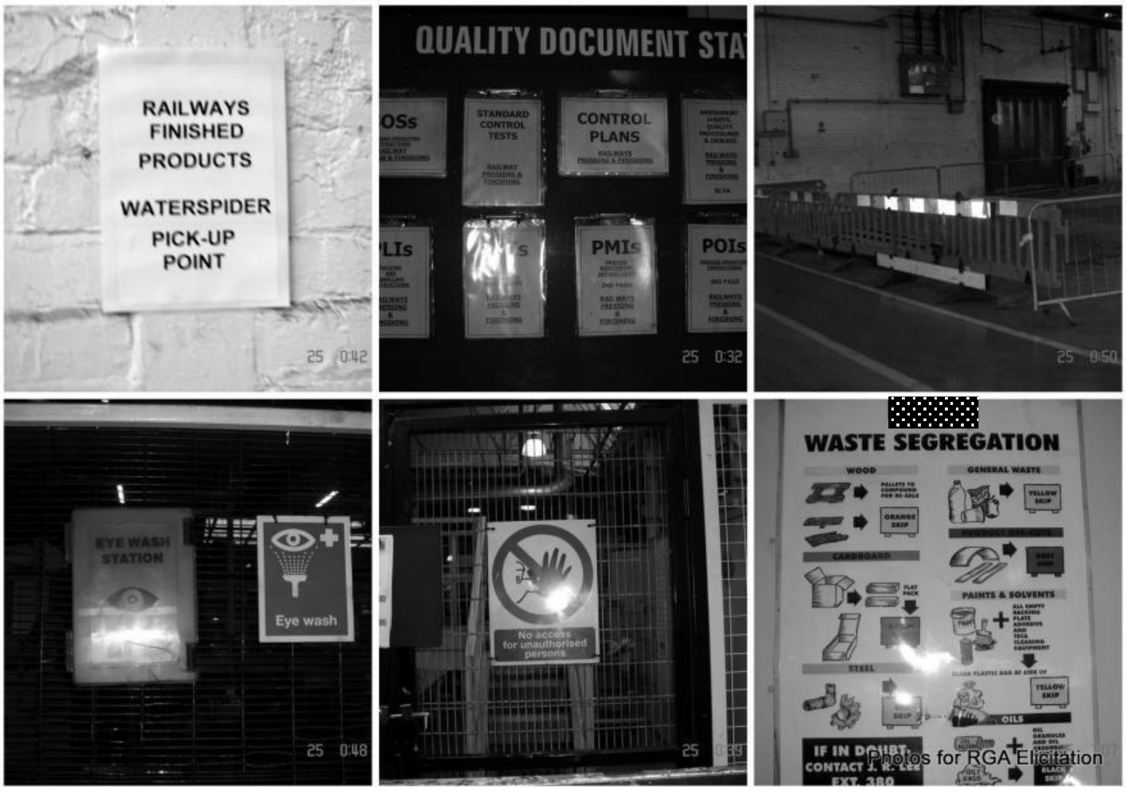


Figure 4-2 – Manager Nos. One – Photographs used for Photo-Elicitation

The results for this manager of the participant-led-photography, photo-elicitation, and ECRS, and the resulting themes are shown below in Figure 4-3.

The first column identifies that this interview was conducted with the manager from value stream number one. The second column headed ‘triadic nos.’ shows the triadic set sequence number, i.e. the sequence number identifying the combination of photographs used for the photo-elicitation activity. In column three I have shown the actual numbers of the photographs used for that particular elicitation. The following three columns show verbatim the comments from the photo-elicitation activity, taken directly from the post-it note records, in respect of the elicited and emergent constructs. Of these three columns, the last one is the record any ancillary comments captured during the interview. The seventh column shows the result from the ECRS activity. The table row order has been sorted according to this seventh column, showing how in this case, twenty elicited constructs were consolidated to ten themes.

Value Stream	Photo-Elicitation					ECRS	
	Triadic Nos	Photos. Nos.	Elicited Constructs	Emergent Constructs	Ancillary Comments	Theme	Unique Construct
1	5	1,3,5	Both area made safe. H&S - Don't go in this area.	Potential accident if you go inside	One is closed area. One is open area.	Awareness in Area	
	6	1,4,5	As before	As Before			
	17	3,4,6	Safety related	Unsafe areas	One is a caged area. Other is open plan area.		
	20	4,5,6	Closed area. Direct instruction for safety	Potential accident	Bent guarding. Using a pokey stick. Must be a solution.	Visual & Verbal	
	19	3,5,6	Closed area. H&S. (Will have an accident)	Open Area. H&S. (Potential for an accident)	One is electronic & one is manual.		
	18	3,4,5	Enclosed area with potential Hazard	Accident - Potential risk			
	15	2,4,5	Safety - Stopping unsafe acts	Operator able to injure themselves.	Both are H&S related.	Injury Awareness	
	16	2,4,6	Essential for running the cell	Quality defects going to customer. Environmental issues.	Waste disposal & quality of production	Quality	
	13	2,3,6	Required to work effectively in the cell	Lack of control in the cell. Not enough instructions	Some are controlled documents by others areas and others are from within this area.	Visual & Verbal Communication	
	10	1,3,4	H&S Photo	Having an accident		Be Alert in Area	
	14	2,5,6	Direct instructions relating to H&S	Safety or environmental problem	Caged area. One is open instruction for everyone		
	11	2,3,4	Visual indicators of risks in those areas	Potential accident	On the barrels it does not really tell you the risk - area just cordoned off	Stop - Do Not Enter	
	12	2,3,5	No access allowed warning - barrier	Not safe conditions. People have access not safe.	Both related to safety. One is electronic. One is manual.		
	3	1,2,6	Op instruction inside the cell perimeter	Instruction for someone outside the cell	Cell perimeter thinking inside/outside cell	Follow Cell Procedure	
	1	1,2,3	Assisting you in your job	Telling you not to do something 'no entry'	Telling you do to something specific. 2nd telling someone else to do the job.		
	8	1,5,6	Both necessary to run consistent to FMOS	Missing deadlines. Not complying with environmental waste disposal			
	9	1,3,6	Impacts the boundary of the cell perimeter	Possible missed order for customer	Pick-up point at one end of the flow. Barriers preventing the train from working in a circular path.		
	4	1,2,5	Effect control of cell. External & Internal	Missing customer deadlines. Products not being taken away.	Outside of control of leaders	Measure the Product	
	2	1,2,4	Instruction to you to do something	No instruction for operators about material or safety	Traffic lights indicating if the job has been done. Part of the TL role is to check eye wash station	Traffic Movement	12
	7	1,4,6	Instruction to op / water spider. H&S / Production	Contamination malfunction FMOS	Ones production instruction. One is environmental segregation		

Figure 4-3 - Manager Nos. One - Constructs & Themes Summary

The Constructs - Approximately twelve of the twenty constructs that emerged from the interview with this manager (photo-elicitation activity) were related to the theme of safety. An additional two of the constructs (number two and seven) were also somewhat related to issues of safety. These comments had some aspects that were related to the logistics of ensuring materials are transported to and from the area, but the elicited comments contained references and phrases that were more broadly associated with issues of safety. The remaining constructs were related to quality or customer delivery deadlines.

Unused Photographs - I have also presented below, in Figure 4-4, the photographs taken by the manager but not used during the elicitation process. I have presented these here because by reviewing them it can be shown if they supported the themes already elicited by the manager or if there was something unique which could have emerged had they been used instead for the photo-elicitation activity.

The top row of three photographs can be seen to be also related to safety, which continues the theme of those used for elicitation. From the bottom row, two are related to cleanliness and tidiness of the area and the last one shows an expiry date of a chemical used as part of the manufacturing process; aligning it to issues relating to product quality. I would argue that if any of these six photographs had been substituted with any of those selected for photo-elicitation, then the overall themes would have remained broadly the same.

Figure 4-4 - Manager Nos. One – Unused Photographs

Discussion - my view is that this environment had created a contingent need for vigilance in terms of safety that was markedly emphasised when compared to other parts of the factory. This is not to say that safety was not mentioned in other areas, however, the manager chose to photograph those elements of the environment he felt to be important and subsequently elicited constructs that were consistent with this perceived need. During the elicitation interview it was apparent to me that safety was being emphasised in relation to the particular products and available technology within this area.

The manager’s responsibility for the safety of the operators is emphasised within this organisation, as I expect it is in most organisations. This is particularly so in environments where there are large machine tools and other processing dangers. It is both an industry wide expectation of management and a legal requirement to ensure safe practices within the organisation. In such an environment the use of visual communication by the managers to affect and reinforce policies and procedures for safety seems sensible and predictable and the elicited themes were consistent with such as focus.

4.1.2 Manager Nos. Two – Light Vehicle / High Volume

The Value Stream - Value stream two consisted of a highly automated continuous flow production line. It produced a handful of different part numbers for just two original equipment (OE) customers. These products were destined for car assembly plants within Europe. Car companies are amongst the most stringent in respect of quality and on-time delivery. In this value stream the process control requirements expected from these OE customers were more demanding in comparison to the other production areas. Typical mandatory requirements stipulated by the customer were statistical process control of critical characteristics and data logging to provide traceability in case of problems.

The Photographs - (Figure 4-5 below). Of the six photographs captured by this manager, five photographs had a common theme in showing various different ways in which the process was being controlled. Four of the photographs showed measurement data relating to the process. A fifth showed a trolley where tooling was being stored in an organised way to ensure any missing tooling was visually apparent. The key theme to emerge was related to control of the process. The sixth photograph was completely different in nature and showed fire extinguishers.

Figure 4-5 - Manager Nos. Two – Photographs used for Photo-Elicitation

The results of the participant-led-photography, photo-elicitation, and ECRS are shown below along with the resulting themes, see Figure 4-6.

Value Stream	Photo-Elicitation					ECRS	
	Triadic Nos	Photos. Nos.	Elicited Constructs	Emergent Constructs	Ancillary Comments	Theme	Unique Construct
2	15	2,4,5	Monitoring aids - tell us we are in control	Don't know if we are in control		Process not in Control - No Evidence	7
	16	2,4,6	Same as before	Same as before.			
	11	2,3,4	Start of process in control	Would not know if we are in control			
	3	1,2,6	quality work station. Measurement and data entry	Not taking measurements			
	4	1,2,5	same as above	Same as before.			
	7	1,4,6	same as above	Same as before.			
	5	1,3,5	Manual measurement & electronic measurement	Not taking electronic measurements			
	12	2,3,5	Readings of start & end of the process	Would we know we are in control			
	13	2,3,6	same as above	Same as before.			
	9	1,3,6	Data visualisation	Not being in control of products being made. Too many variables			
	10	1,3,4	Both recording. Visual monitoring aids	Would not know we are in control of the products			
	17	3,4,6	Monitoring systems	How would we know we are in control			
	18	3,4,5	Same as before	Same as before.			
	19	3,5,6	Same as before	Same as before.			
	20	4,5,6	Same as before	Same as before.			
	6	1,4,5	Used for measurement. Pad thickness. Oven temp.	Don't take measurements of readings			
	2	1,2,4	Monitoring oven temp. Monitoring pad statistics	Not written graphs electronic	Previous handwritten on ops cards. Does away with paper	Measurements to Products and Equipment - To show we are in Control	8
	1	1,2,3	Monitors to provide information	Writing down by hand	High technology		
	8	1,5,6	Both visual aids.	People not informed of fire exit locations or tool availability		Visual	
	14	2,5,6	Visual location fire extinguisher & next tooling	People not informed of fire Ext. locations or tool availability	Shadow board is a good visual aid. Easy to see if something is missing		

Figure 4-6 – Manager Nos. Two - Constructs & Themes Summary

The Constructs - In the above table the first eighteen of the twenty listed constructs were connected to issues of measurement or monitoring of the process. These were split by the manager into two broad headings relating to process measurement (construct number seven in the final column) or more focussed on product measurement (construct number eight). The remaining two constructs (shown in the final two rows of the above table) were connected to the theme of safety. They included elicited comments such as fire extinguisher and fire exits.

Unused Photographs - Presented below are the six photographs that were not selected for photo-elicitation (Figure 4-7). Five of these images also have process control related themes. They show a range of visual communication aimed at the operator to maintain control of the process; standard operating procedures, machine maintenance procedures and quality standards board. One of the photographs shows a machine isolation procedure which could arguably lead to a theme relating to safety. However, one of the photographs already used for elicitation did show a fire extinguisher, but the resulting theme from the manager was relatively ambivalent about its meaning. I think that the themes emerging from the photo-elicitation activity would still have emerged even if the photographs had been substituted for the ones shown below.

Figure 4-7 – Manager Nos. Two – Unused Photographs

Discussion - In this value stream the environment and key stakeholders, i.e. Original Equipment customers, have created a contingent need which has partly been met through the use of visual communication. The photographs and elicitation are focussed on those aspects of the shop-floor that provide control of the process.

In contrast to the photographs and themes elicited in value stream number one, in this value stream they were less associated with health & safety, despite these two areas being just a few metres apart. Just two photographs from twelve showed this theme compared to the remaining ten being related to production or process control. I believe that this is because in this area there was relatively less manual handling due to the use of powered conveyors to automatically transfer parts from machine to machine. Also there were relatively less machine changeovers due to very few varieties of part numbers being manufactured.

4.1.3 <u>Manager Nos. Three - Light Vehicle/Medium Volume</u>

The Value Stream - This value stream was situated physically between value stream two and four (see Figure 3-6). It had automation levels that were lower than those of value stream two but somewhat greater than those of value stream four (which I will speak about in the next section). The value stream produced around ten different products on relatively automated equipment. These machines, although not connected with powered conveyors as in value stream two, were furnished with magazines such that the operators could load/unload a number of components at a time. This gave the opportunity for a single operator to run more than one operation simultaneously. It meant that the output from this area was dependant on the operator performance whereas the output from value stream two was somewhat more dependent on machine reliability.

This particular area had a declining profit margin for several years despite a year on year increase in volumes. In this context the focus of the manager can be better understood. The machine capacity and labour was relatively fixed by design but the area was under pressure to utilise both of those assets more effectively.

The Photographs – (Figure 4-8 below). The six photographs captured by this manager during the photo-elicitation stage showed a number of seemingly different threads. Two of the photographs were of visual boards designed to capture production output data from different parts of the value stream. These were referred to as "hour by hour" boards, because the data was collected by the operator on an hourly basis. One photograph was of a board showing the planned production order sequence. This is where the staff from the production planning department indicated by writing the sequence (and quantity) in which the required parts were to be produced. One picture related to a board showing the planned maintenance schedule and maintenance procedures. One picture related to improvement actions that had been discussed and agreed to improve the capacity of the machine tools. The final picture was of the minutes from the monthly health and safety meeting, which had been displayed on a communication board.

Figure 4-8 - Manager Nos. Three – Photographs used for Photo-Elicitation

The results of the participant-led-photography, photo-elicitation, ECRS and the resulting themes are shown below in Figure 4-9.

	Photo-Elicitation					ECRS	
Value Stream	Triadic Nos	Photos. Nos.	Elicited Constructs	Emergent Constructs	Ancillary Comments	Theme	Unique Construct
3	7	1,4,6	Improvement (Same as before)	Same as before	Missing 5S Standards. Relying on operator knowledge to do it	Improvements or lack of	9
	18	3,4,5	Improvements	Not bother or improvements have already been done			
	19	3,5,6	Improvements	Don't make improvements			
	16	2,4,6	Improvements	Not bothered making the improvements	Many actions & too long to complete. H&S - does not send out the right message		
	20	4,5,6	Productivity improvement	Not doing anything "get what you always got"	SMED - we've never seen it through - Production is King		
	6	1,4,5	Improvement related	Don't make improvements	Outstanding actions are not completed - always this way. Resource related		
	8	1,5,6	Same as before	Same as before			
	9	1,3,6	Same as before	Same as before			
	17	3,4,6	Improvements (Same as before)	Same as before. Ongoing outstanding actions.			
	10	1,3,4	O/P tracker	Not O/P Tracker (Same as before)	As a TL looking at this all the time. Are they hitting the target? MV1 - all 3 shifts working in different ways - TL covers this.	Production Tracking / Output	10
	1	1,2,3	Output trackers (visual) available to everyone	No o/p tracker. Nobody would know the o/p (performance)	I use it - see what other shifts have done. The problems they have had - hand over, if it is OK. TL's handover, technician can also review it.		
	12	2,3,5	Production scheduling	Making whatever is easiest	Monitoring, checking if machine is running	Production Scheduling	
	13	2,3,6	Same as before	Same as before			
	14	2,5,6	Same as before	Same as before			
	15	2,4,5	Same as before	Same as before			
	11	2,3,4	Daily measures I/P & O/P.	Make whatever they want. SAB. No measure.			
	2	1,2,4	Input and Output monitoring	Making whatever is next or the easiest one.	Information is late coming. Typically 12:00 in the morning.		
	4	1,2,5	2-way communication. Telling what to produce. Tracker - telling what done	Not having information. Ops doing what they want			
	5	1,3,5	Same as before	Same as before.			
	3	1,2,6	Visibility of problems relating to certain part nos.	Unaware of problems relating to references	MV1 Kanban required. Overproduction. 5S Issues	Kanban - Over Production	

Figure 4-9 – Manager Nos. Three - Constructs & Themes Summary

The Constructs -The first nine elicited comments in the above table were directly related to sustaining or improving the productivity in the area; productivity defined as a measure of output pieces per operator per labour hour. The next two elicitation comments (shown as triadic set numbers ten and one) were in relation to production output tracking. This seemed to be directly linked to the constructs related to productivity, highlighted in the first nine pairs of elicitations discussed above. The last nine elicited comments (from numbers twelve to three) were related to production planning.

Unused Photographs - I also reviewed the six photographs captured during the participant-led-photography but not used in the elicitation (Figure 4-10 below). Five out of six of these were also related to scheduling or capacity issues and just one was related to quality standards.

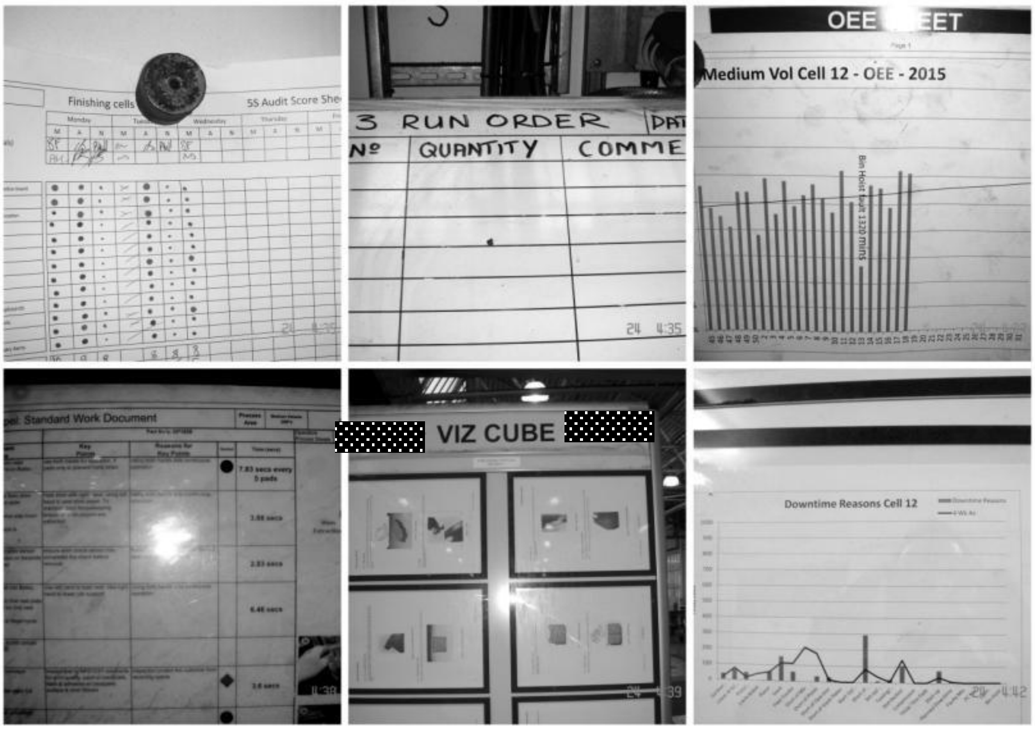


Figure 4-10 – Manager Nos. Three – Unused Photographs

Discussion - In this value stream area, similar to the first two areas, the visual communication that was selected for the participant–led-photography and the subsequent elicitation was connected to the contingent needs of the area. The area was under pressure to improve its performance and this theme emerged more strongly than in the previous two elicitation interviews. The profit margin issues were known by the manager and themes related to this were emphasised in the use of visual communication.

At the shop-floor level the issue of productivity was correlated with the pieces produced by each operator as this translated directly to the cost of making each part. It was used as a correlated measure because the remaining costs were considered as being relatively fixed. The labour productivity was an operational level business metrics that the production team could focus on to contribute to sustaining and improving the overall profitability of the area. The production output tracking also seemed to be directly linked to the constructs related to productivity. The managers were expected to monitor the output against target on an hourly basis. This was to ensure that the capacity of the area was being effectively deployed as well as ensuring that the planned production was met.

The area had a relatively high variety of part numbers which resulted in a need for careful planning of the sequence of work. The area was planned on a daily basis with changes sometimes being made to the run order due to problems with capacity (machine or labour availability) or the lack of components (or materials) to manufacture parts. Virtually all of the twenty elicited comments referred to the issues of planning, delivering against that plan, and making improvements to the productivity of the area, i.e. delivering the plan more profitably.

It was an area with a relatively high amount of manual handling and safety was mentioned in one of the elicitations.

4.1.4 Manager Nos. Four - Light Vehicle / Low Volume

The Value Stream - This area had the highest variety of part numbers compared to all other areas in the factory. It also had the highest number of operators due to the predominantly manual machines. Due to the relative lack of automation, there was a significant amount of manual handling taking place. The lack of connectivity between subsequent processes required semi-finished products to be stored between processes in an orderly (visual) way.

The Photographs – (Figure 4-11). The photographs captured during the participant-led-photography by this manager initially looked like they had more varied themes than those from the previous value streams. One photograph portrayed the shift kick-off meeting communication board, used by the managers and operators to provide feedback about the performance of the area. The key communication at this meeting was about the daily internal scrap levels, external customer quality complaints, safety metrics, production output versus target and productivity. Of the remaining photographs, one showed a shadow board for cleaning equipment and another was closely related to this, showing a checklist for the cleaning schedule. Of the remaining three, one was of a storage rack, one was of a board showing quality related documents and the last was of a board that indicated the operator versus machine assignment.

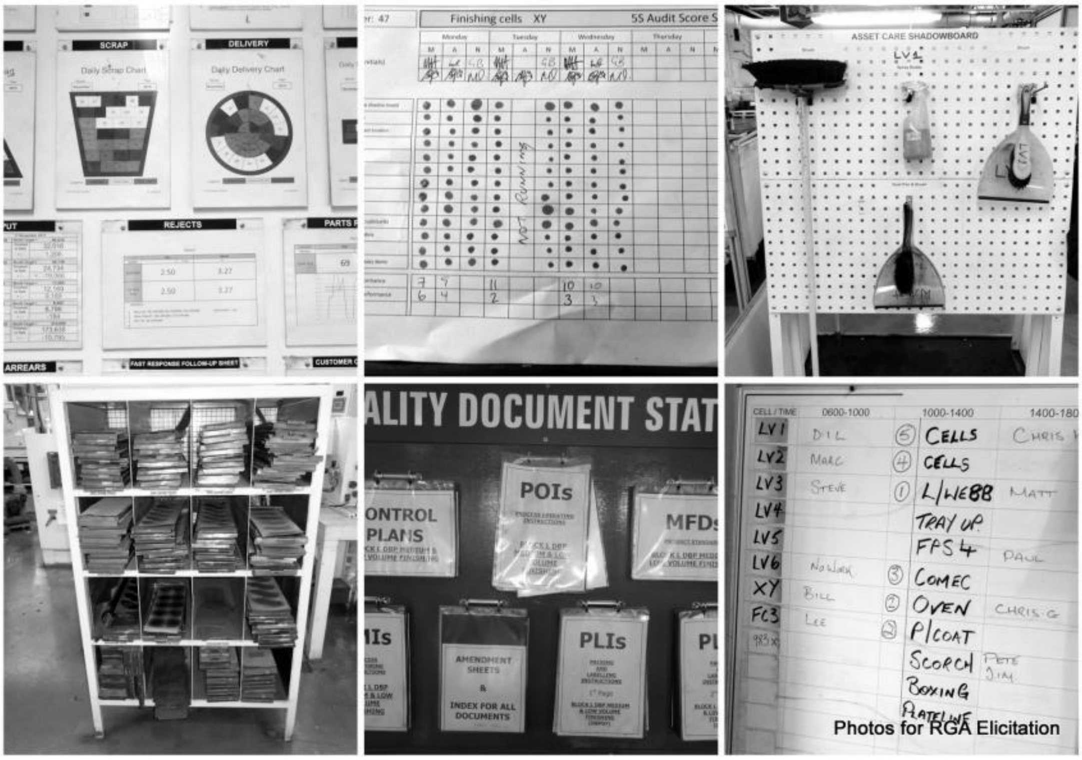


Figure 4-11 - Manager Nos. Four – Photographs used for Photo-Elicitation

The results of the participant-led-photography, photo-elicitation, ECRS, and the resulting themes are shown below in Figure 4-12.

Value Stream	Photo-Elicitation					ECRS	
	Triadic Nos	**Photos. Nos.**	**Elicited Constructs**	**Emergent Constructs**	**Ancillary Comments**	**Theme**	**Unique Construct**
4	**2**	**1,2,4**	Communication. Operator involvement	Operator doing something (work) but not sure about results	Tells operator how well they are doing. (safe working for example). Working to procedure	Communication Throughout	**1**
	19	**3,5,6**	Information telling what to do. Working to sequence.	Unaware wrong products	Working to procedures		
	4	**1,2,5**	Giving me information	No information			
	9	**1,3,6**	Communication. Operator involvement	No communication or not knowing what they are doing			
	6	**1,4,5**	Communication.	People not knowing where we are and where we are doing	Feedback. Informing how well or badly we are doing		
	12	**2,3,5**	Telling information	Not clear what goes where	Operator taking care ensuring work station is tidy at start of shift.		
	7	**1,4,6**	Communication	Not Knowing	Awareness Creating		
	8	**1,5,6**	Communication	Not Knowing	Making people aware		
	14	**2,5,6**	Telling operator what to do	No communication	Making operator aware		
	3	**1,2,6**	Operator involvement	Untidiness	Operator taking control of his workstation		
	11	**2,3,4**	Everything in its place	Untidy equipment everywhere	Nice to see everything is its place	Dusty & Dirty	**2**
	18	**3,4,5**	Everything in its place. Tidiness. Same as before	Shabby. SAB. Untidiness	Nice to see everything is its place		
	1	**1,2,3**	Cleaning	Dirty factory	Place for everything and everything in its place. But misplaced items		
	15	**2,4,5**	Tidiness	Untidy.	Operator Keeping note of keeping area tidy		
	16	**2,4,6**	Cleanliness tips	Untidiness clutter	Tidy		
	17	**3,4,6**	Same as before	Same as before	Same as before		
	13	**2,3,6**	Cleanliness / Procedures	Untidiness	Operator working to procedure		
	20	**4,5,6**	What job to do next. How to do it.	Chaos. Ops not knowing what to do. Wrong shims and Temps. Packing in wrong containers		Informing	
	10	**1,3,4**	Work related. Both for work. Shim (hot) and cleaning. "Right place for everything".	Unorganised	Tidy	Operator Listening - Working to Procedures	
	5	**1,3,5**	Same as before. Communication	Same as before.	Making people aware.	Working to Procedure	

Figure 4-12 – Manager Nos. Four - Constructs & Themes Summary

The Constructs - Despite what initially looked like a wider range of photographs, the results of the elicitation activity were broadly broken down into three groupings. Eleven of the constructs from the elicitation were related to work place orderliness and tidiness. The remaining nine were related to either providing operators with information about the performance of the area or the sequencing of customer orders through the area.

Unused Photographs - The six photographs captured during the participant-led-photography but not used during the elicitation phase are shown below in Figure 4-13. These photographs show planning boards, tooling used for machine changeover, storage of parts, materials used for the storage of parts, a board used to record component shortages, and a table which is used to organise the workplace. These are all consistent with the other photographs from this manager and only further emphasise the elicited themes.

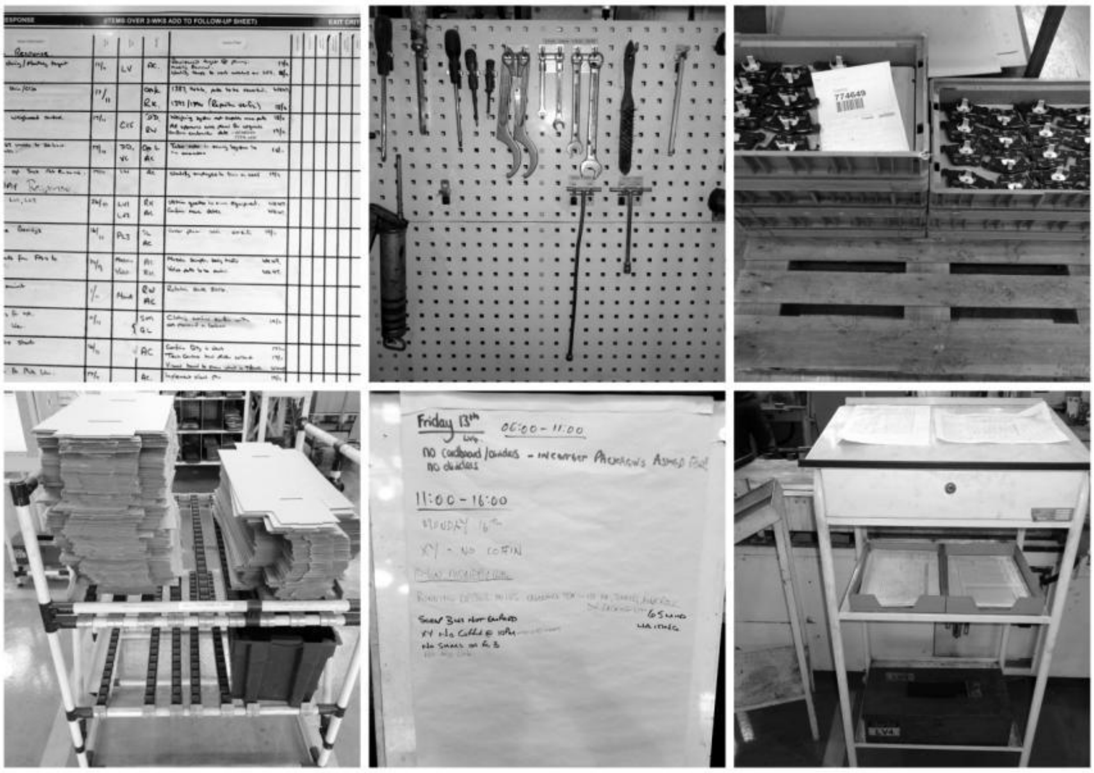


Figure 4-13 – Manager Nos. Four – Unused Photographs

Discussion - The emphasis by this manager of the use of visual communication for feedback and communication for the operators is understandable. The operators were kept informed of progress towards the key metrics to ensure their alignment with those metrics. From a production management perspective, the greater concentration of operator's meant that the work needed to be sequenced and scheduled so that they were kept gainfully and productively employed. Problems with workflow, machine or materials availability, or the requisite operator's skills, could mean that productivity, which as a shop-floor performance indicator is connected with profitability, would be negatively impacted. The elicited constructs that were subsequently consolidated to "communication throughout" seem to align with these needs.

The elicitation comments relating to "everything in its place", i.e. workplace tidiness, were in recognition of the importance of keeping the work areas organised despite the constant moving and storing of products between processes. In addition, the variety of part numbers produced in this area required the machines to be switched from producing one part variety to another on a regular basis, sometimes several times during a given shift. This required alternative tooling for the machines to be easily accessible and readily (visually) located. Both of these factors increased the need for visual communication relating to an ordered workplace.

4.1.5 Manager Nos. Five - Light Vehicle / High Variety

The Value Stream - The machine tools used in this value stream were several decades old, having been installed for production volumes far in excess of what was now being demanded. This was historically a high volume production area manufacturing just a small number of product types. However, the current demand was for a much higher variety of different products. Effectively this meant that the machines were oversized for what was now required, with the added difficulty of requiring frequent changeovers to different part numbers. The stand-alone design of the machines meant that a great deal of manual handling was necessary to load and unload each machine and to transfer work between machines. As in value stream number one, components in this area were relatively large with a similar strong focus on quality.

The Photographs – (Figure 4-14 below). From the photographs that were used for the photo-elicitation, captured by the manager, three photographs related to health & safety. One was of a defibrillator, one of a fire extinguisher and the third of an eye-wash station. This last photograph also captured in the same image a rack used to store production orders. Of the remaining three photographs, two showed quality standards boards, and the final one was of a tooling storage rack.

Figure 4-14 - Manager Nos. Five – Photographs used for Photo-Elicitation

The results of the participant-led-photography, photo-elicitation, ECRS and the resulting themes are shown below in Figure 4-15 for this manager.

Value Stream	Photo-Elicitation					ECRS	
	Triadic Nos	Photos. Nos.	Elicited Constructs	Emergent Constructs	Ancillary Comments	Theme	Unique Construct
5	2	1,2,4	Health & Safety. Same as before	H&S. Same as before		Health & Safety	
	7	1,4,6	H&S. Same as before	H&S. Same as before	Direct spot. Can see / locate them		
	8	1,5,6	H&S. Same as before	H&S. Same as before			
	6	1,4,5	H&S. Same as before	H&S. Same as before	TL and FM people know where they are. What about contractors? Are they shown these points?		
	9	1,3,6	Same as before	Same as befre			
	10	1,3,4	H&S related	Not being able to find them (H&S)	Very visual. Everyone can see them. Serve a big purpose.		
	11	2,3,4	Same as before	Same as before			
	12	2,3,5	Same as before	Same as before			
	19	3,5,6	Quality workstations	Wrong info on ops cards		Workstations and Quality	5
	13	2,3,6	All related to quality	Incorrect information on quality documents			
	3	1,2,6	Safe guarding quality (preset tooling)	Customer concerns	If have a defect then have to get out of the situation. Set-ups, have to back in the correct location.		
	4	1,2,5	Same as before	Same as Before			
	18	3,4,5	Quality workstation. Linked together	Mis-match. Customer concern	Viz Cube would be better. Adding POI's etc.		
	14	2,5,6	Same as before	Same as before			
	15	2,4,5	Same as before	Same as before			
	16	2,4,6	Same as before	Same as before			
	17	3,4,6	Same as before	Same as before	Same as before		
	20	4,5,6	Operations card. Giving required set-ups	Having to build stuff up for set-up	Pre-set tooling. Get less rejects.	Operator Cards - Quality Set-ups	6
	1	1,2,3	Info about products being made and where gone wrong.	Giving all the info we need to work to	Both visual to help us out.		
	5	1,3,5	Same as before. Ops card is guideline all the way through	If quality docs. Not related to ops card. Would create a problem.	Could be laid out better. Quality Station.		

Figure 4-15 – Manager Nos. Five - Constructs & Themes Summary

The Constructs -Twelve of the twenty themes were related to issues associated with having to constantly set-up the machines for the manufacture of different parts and ensuring that the quality of the product was under control.

These twelve along with the remaining elicitation comments were consolidated into three key themes. These were health & safety, quality, and machine set-up information. In reviewing these themes I considered that machine set-up and quality were also directly connected. This is because there is a potential impact on quality created by disturbing the machine to conduct a changeover to a different part number.

Unused Photographs - Considering the remaining six photographs (shown below in Figure 4-16) captured during the participant-led-photography but not selected for the photo-elicitation, these also predominantly showed the same themes mentioned above, i.e. health & safety and machine-set-up.

Figure 4-16 – Manager Nos. Five – Unused Photographs

Two of the photographs showed production orders / production planning boards and a third showed how materials were stored and visually managed to ensure that they were easily located. This was important considering the variety of part numbers manufactured in this area and the need for operatives to be able to readily locate materials.

Of the remaining three photographs, two were related to health & safety. One showed photographs and names of the first aiders in the area, and the second was of a fire extinguisher location. The last was the shift-kick off communication board which provided feedback to the operators about the targets and performance of the area.

Overall these photographs reinforced the themes of those that had been used for the photo-elicitation activity; the themes relating to health and safety and machine set-up/quality. As in the previous elicitation interviews, the themes that emerged were based on the demands of the production equipment in the context of the customers' needs.

Discussion - The machines in this area were designed for large batch or continuous running operation. The equipment was suited to making components that were used on relatively low powered small cars. The general increase in car performance, correspondingly requiring a different design of component, had gradually eroded the volumes in this area over the last few decades. However, due to the financial crisis of 2007-8 there was resurgence in small car sales that in turn increased the demand for products from this area. This demand however was fragmented across many different product types so although the equipment was somewhat automated, the need for frequent changeovers brought the operators into close contact with the machines. In my opinion, it is in the context of frequent machine changeovers that the theme of quality was identified.

The nature of the layout, equipment size and need for frequent changeovers had, as with value stream one, created a contingent need for a focus on safety.

4.1.6 Manager Nos. Six – Materials Mixing Department

The Value Stream - This production area contained just a handful of large stand-alone machines. These machines processed raw materials which were supplied to the other five value streams mentioned above. It was a production area treated effectively as an internal supplier to the rest of the factory.

The products produced in this area were expensive with a relatively limited shelf-life. They consisted of multiple chemical ingredients mixed together to form a batch of material. The individual component chemicals comprising the ingredients were sourced from a large number of different suppliers, often with long lead times. Managing the supply chain to ensure that the right materials in the right quantities were available to satisfy the daily demand, without excessive stock holding, was considered problematic.

The Photographs – (Figure 4-17). In this value stream, the manager captured a range of seemingly different images. The first was of an electronic board monitoring real time consumption of a product used in value stream two. The steady supply of materials from this area to that value stream was considered crucial due to potential financial penalties to the organisation if that production area failed to deliver products to its customer on time. A second photograph was of a board used during the operator shift-kick-off meeting. A third was of a white board that was used to record any missing raw materials that were preventing the planned production from being followed. A fourth was similar to the photograph seen in value stream five, relating to details of the first aiders in the section. Another photograph was of a board referred to as a “fast response board”. This was a list of current problems in the area and details of any agreed actions. The last photograph was of a bill of materials screen. This showed the recipe and materials availability for the products supplied by this production area to value stream number two mentioned above.

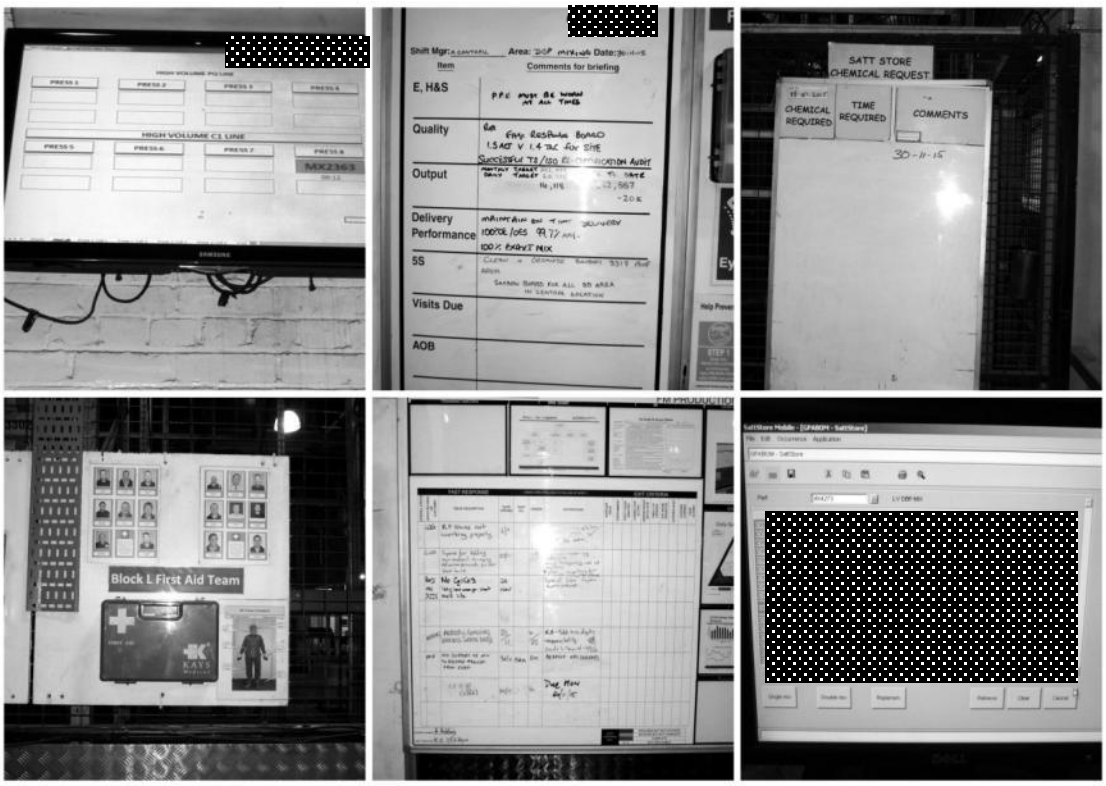


Figure 4-17 - Manager Nos. Six – Photographs used for Photo-Elicitation

The results of the participant-led-photography, photo-elicitation, ECRS, and the resulting themes are shown below in Figure 4-18 for the manager from value stream number six.

Value Stream	Photo-Elicitation					ECRS	
	Triadic Nos	**Photos. Nos.**	**Elicited Constructs**	**Emergent Constructs**	**Ancillary Comments**	**Theme**	**Unique Construct**
6	**7**	**1,4,6**	Order sequence. Mixing, chemical, labour deployment	Not knowing what mix or chemicals are required. None communication. Not flowing	Only as good as the operative. Has to flag it up on his machine to update the board (suspect to human error)	Mix Order and Sequence of Mixing	**3**
	8	**1,5,6**	Same as before	Same as before	Same as before		
	17	**3,4,6**	trigger'. Recipe - ingredients. Pull system into sat stores. Order of chemical delivery also visual.	Running out of mix (stopping cells etc)		Chemical Ordering	
	9	**1,3,6**	Pull system. Chemicals flowing chemicals. Improving productivity	Waiting for chemicals (bad for productivity). Open to human error.	Running out of chemicals. Knock on effect in the factory. Water spider not bringing material	Waiting for Chemicals	
	1	**1,2,3**	Key for running, deployment employment	No information. Late mixes. Later orders. Deadlines not met. Line stoppages. Orders lost	Visual board. Informative, useful. Productive. Essential.	Mixes Times Needed	
	10	**1,3,4**	Same as before	Same as before	Planning		
	11	**2,3,4**	Same as before	Same as before			
	5	**1,3,5**	Colour coding. To tell time remaining. Time indicator.	Process stopped. Too late fulfilment		Cells Stopped	
	2	**1,2,4**	Factory communication (essential communication)	Open to human error (people not putting visits on)		Factory Communication	
	3	**1,2,6**	Same as before	Same as before			
	4	**1,2,5**	Same as before	Same as before			
	20	**4,5,6**	people' first aiders and responsible people for actions. (Essential to know your first aiders)	Impersonal. People not just numbers.	Measuring progress. Measuring problems. Highlighting main problems. 'Pattern forming' (missing chemicals)	First Aiders / People	**4**
	12	**2,3,5**	Communication boards. Overview of problems. Inform about visits.	What are major problems. Not tracking performance. Lack of preparation. Not maintaining quality. Don't know if ahead or behind. No pattern forming. Bad for morale.	Good idea. But need reactivity. Need people to be more in the spotlight.	Communication of Performance	
	13	**2,3,6**	Same as before	Same as before			
	18	**3,4,5**	Same as before. Problem tacking focussed	Same as before		Problem Tracking	**11**
	19	**3,5,6**	Same as before	Same as before			
	14	**2,5,6**	Same as before.	Same as before.	Easy to read. Informative about visitors (customers)	Visual	
	15	**2,4,5**	Same as before	Same as before	Same as before		
	16	**2,4,6**	Same as before (People orientated)	Same as before			
	6	**1,4,5**	H&S. (1306 phenol resin).	Life threatening. Injury if first aid team not known. Life changing	Bad for morale if H&S not seen as being important.	H&S - First Aiders	

Figure 4-18 – Manager Nos. Six - Constructs & Themes Summary

The Constructs - The manager identified eleven themes. These could be consolidated to three key themes; ‘production order control’, ‘health & safety’, and ‘operator communication / feedback’.

Unused Photographs - The six photographs captured during the participant-led-photography but not selected for photo-elicitation also had similar themes, see Figure 4-19 below. All six photographs of visual communication were seen to be directly related to production planning, or operator communication. In the images below there are planning boards, problem tracking boards, production orders and recipe information. Again I believe that the substitution of these photographs for those used in the photo-elicitation would have delivered similar themes.

Figure 4-19 – Manager Nos. Six – Unused Photographs

Discussion - Similar to the first five value stream, the images captured and subsequent elicitation was consistent with the contingent needs of the environment. The combination of a perishable products, produced with ingredients with long procurement lead-times, a large number of different suppliers, and limited flexibility, all added up to make production planning an important theme for this area. The five value streams requiring materials from this production area were themselves subjected to customer demand changes, machine breakdowns and labour unavailability. This superimposed a further level of uncertainty about the demand pattern and hence an even stronger emergent focus in relation to planning. The communication and feedback themes are more easily grasped having considered the above context.

4.1.7 Results of Photo-Elicitation

In the first section of this chapter I have presented, for each of the six managers, the findings relating to their psychological constructs. I have briefly described the photographs they used for their photo-elicitation activity and how these translated to constructs and finally consolidated themes. The use of participant-led-photography, photo-elicitation and ECRS has enabled access to those constructs the managers were using to make sense of their environment and in doing this has fulfilled the first objective towards achieving the overall aim of this research, i.e. extracting psychological constructs from the managers. I have also reviewed the six photographs that were captured by each of the managers but were pooled in reserve for use later in the research. These photographs also reinforced the themes that had been elicited, indicating the utility of these methods.

The key findings from this elicitation activity were that the emergent constructs were strongly connected to particular dominant issues associated with the operating environments, as framed by the individual managers. Examples of this were:

Value stream one - the environment was characterised by small batches, requiring frequent machine changeovers, of large heavy products manufactured on relatively dated stand alone equipment. The emergent themes were mostly focused on safety.

Value stream two - was a heavily automated production line with the role of the operators associated with monitoring the production process. Here the themes that emerged were connected with the product quality and product/process data collection.

Value stream three - had relatively less automation and a greater variety of products. This particular area was being challenged because of deteriorating margins despite increasing volumes. The two themes that emerged were the need to schedule these multiple different part numbers, and driving improvements to sustain and improve the profit margin.

Value stream four - was of a high variety, small batch production area dominated with a large number of manual processes. This meant that a certain level of inventory was necessary to keep people gainfully occupied, but at the same time this had to be managed to keep the workplace organised. The themes that emerged here were connected with orderliness, scheduling, and the need for feedback to the operators about the performance of the area.

Value stream five - was a low volume high variety area with very large, dated equipment. The design of the equipment was unsuited to the smaller batch production runs now being produced. The themes that emerged were linked to the need for planning, machine set-up, quality and safety.

Value stream six – this value stream was effectively an internal supplier, supplying the first five value streams with what they used as input raw materials for their processes. These products, with relatively short shelf-lives, required a large range of raw ingredients. This had to be scheduled and managed through often long supply chains. The key themes in this area were a focus on raw ingredients, their availability and scheduling. It was also about providing feedback to the operators about how well they were doing in supporting their customers.

The above findings are significant in their own right as well as when considered in the context of visual communication. It highlights how the managers are intimately bound within their value streams and its imperatives and how these imperatives can be quite localised. Bordering areas, often separated by a mere line painted on the floor, provide a contrasting array of imperatives.

A range of internal and/or external influences were driving the focus themes for each value stream, i.e. types of equipment, levels of automation, batch sizes, variety of products, business pressures such as profit margins, product shelf-life etc. These factors emerged in what the managers selected to photograph as well as elicited as being dominant in their areas.

The findings that different areas could behave relatively independently are consistent with the design of the organisation. Automotive UK had been differentiated to discrete production areas (value streams) with dedicated production teams. The purpose of creating these value streams was to enable the local production teams to manage and align themselves with the value stream imperatives. The findings, by the use of the above methods, confirmed that the respective needs of the value streams were different from each other and that these dominant themes from within those environments were identified by the managers.

The fulfilment of the first research objective was important to enable the next objective to be completed. This was the creation of a measurement instrument to measure visual communication. This is described next.

4.2 Questionnaire – Design, Administration & Analysis

Completing the first three steps of the research methods resulted in each of the managers having identified their individual unique themes. I then took these individual themes and consolidated them further to arrive at a list of ten themes. These ten themes were used in the last phase of data collection to create and administer a questionnaire, shown as step 4 in Figure 4-20 below.

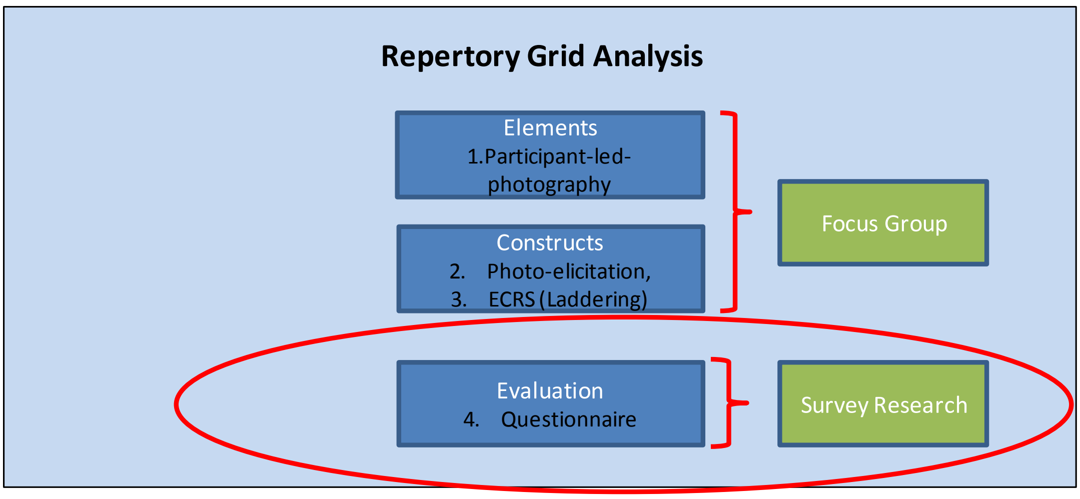


Figure 4-20 - Research Methods – Repertory Grid Design

In the following section;

- There is a short explanation of the translation of these ten themes to headings suited to being used as pole labels, and how these have been used to create a questionnaire (as discussed earlier in the research methods chapter),
- Examples are provided from the questionnaire to show how the themes have practically been used as phrases and labels within the questionnaire.
- The questionnaire was administered to 12 managers and 18 operators. The resulting data was analysed using contingency tables to assess the level of agreement between intended and interpreted meaning. In this chapter, details are provided to explain how this was achieved. Also there is an explanation of the use of the Fisher exact test to establish that the correlation data is significant.

4.2.1 Creating, Administering and Analysis of the Questionnaire

To determine the visual communication correlation (intended and interpreted), the themes generated by the six managers were used to create a questionnaire. In the first part of this section I have explained in more detail of how the elicited themes were used to achieve this.

Figure 4-21 below is a summary table with comments added to help explain how the above ten themes were translated to wording suitable for the questionnaire. The detailed table of analysis can be found in Appendix K.

In the table below the columns headed ECRS show the ten consolidated themes that emerged from the above analysis and review. These themes were translated to bi-polar questions suited for use in the questionnaire. In line with the recommendations from Dillman (2007) about phrasing and formatting questionnaires, a ‘common stimulus’ phrase (Dillman 2007) that introduces each of the questions was included. The purpose of this was to orientate the person filling in the questionnaire to the question being asked. The sections headed ‘left hand pole’ and ‘right hand pole‘ show the pole labels for each of the ten questions.

Identifies the manager / value stream

'Theme' shows the consolidated themes that I considered unique that emerged from the ECRS activity

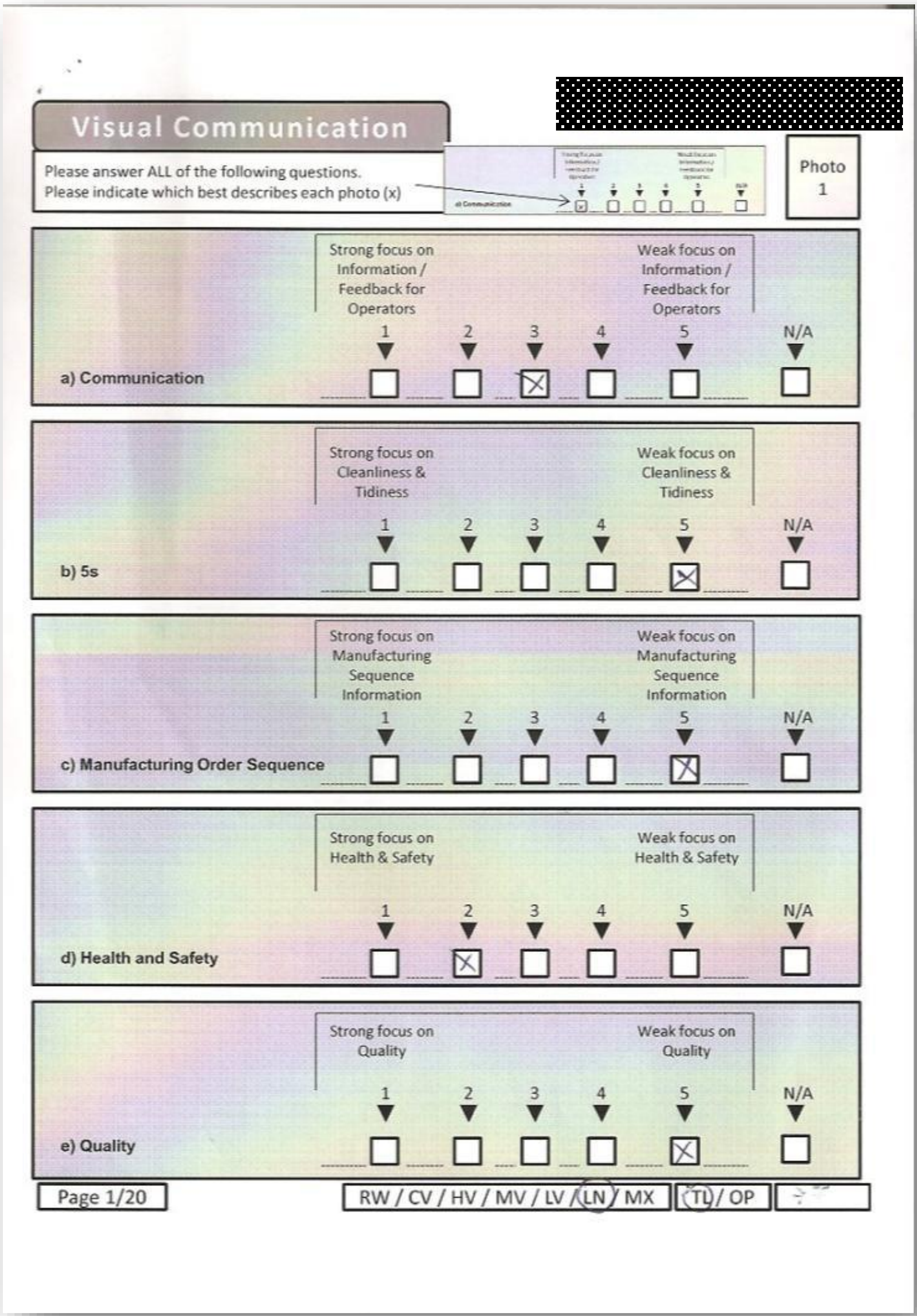
The common stimulus is a short phrase to orientate the respondents of the questionnaire.

Pole labels used in the questionnaire

	ECRS		Questionnaire Design		
Value Stream	**Theme**	**Unique Construct**	**Common Stimulus**	**Left Hand Pole (Questionnaire)**	**Right Hand Pole (Questionnaire)**
2	Process not in Control - No Evidence	7	**Process Control**	**Strong focus on Process Control**	**Weak focus on Process Control**
	Measurements to Products and Equipment - To show we are in Control	8	**Measurement & Recording**	**Strong focus on Measurement & Recording**	**Weak focus on Measurement & Recording**
3	Improvements or lack of	9	**Improvements**	**Strong focus on Making Improvements**	**Weak focus on Making Improvements**
	Production Tracking / Output	10	**Production Ouput**	**Strong focus on Production Output Tracking**	**Weak focus on Production Output Tracking**
4	Communication Throughout	1	**Communication**	**Strong focus on Information / Feedback for Operators**	**Weak focus on Information / Feedback for Operators**
	Dusty & Dirty	2	**5S**	**Strong focus on Cleanliness & Tidiness**	**Weak focus on Cleanliness & Tidiness**
5	Workstations and Quality	5	**Quality**	**Strong focus on Quality**	**Weak focus on Quality**
	Operator Cards - Quality Set-ups	6	**Set-Up Information**	**Strong focus on Set-Up Information**	**Weak focus on Set-Up Information**
6	Mix Order and Sequence of Mixing	3	**Manufacturing Order Sequence**	**Strong focus on Manufacturing Sequence Information**	**Weak focus on Manufacturing Sequence Information**
	First Aiders / People	4	**Health & Safety**	**Strong focus on Health & Safety**	**Weak focus on Health & Safety**

Figure 4-21 – Theme to Questionnaire Translation

The first five questions of the resulting questionnaire sheet, based on the above table, are shown below in Figure 4-22 below.



[redacted]

Visual Communication

Please answer ALL of the following questions.
Please indicate which best describes each photo (x)

Photo 1

	Strong focus on Information / Feedback for Operators 1	2	3	4	Weak focus on Information / Feedback for Operators 5	N/A
a) Communication	☐	☐	☒	☐	☐	☐

	Strong focus on Cleanliness & Tidiness 1	2	3	4	Weak focus on Cleanliness & Tidiness 5	N/A
b) 5s	☐	☐	☐	☐	☒	☐

	Strong focus on Manufacturing Sequence Information 1	2	3	4	Weak focus on Manufacturing Sequence Information 5	N/A
c) Manufacturing Order Sequence	☐	☐	☐	☐	☒	☐

	Strong focus on Health & Safety 1	2	3	4	Weak focus on Health & Safety 5	N/A
d) Health and Safety	☐	☒	☐	☐	☐	☐

	Strong focus on Quality 1	2	3	4	Weak focus on Quality 5	N/A
e) Quality	☐	☐	☐	☐	☒	☐

Page 1/20 RW / CV / HV / MV / LV / LN / MX TL / OP

Figure 4-22 - Questionnaire Design (Format)

Having designed the questionnaire, it was administered according to the research design and methods identified earlier. Ten photographs were selected from the pool of unused images captured during the participant-led-photography, by the six managers. These are shown below (Figure 4-23). Each of these photographs was rated using the questionnaire by each of the twelve managers (two per value stream) and eighteen operators (three per value stream).

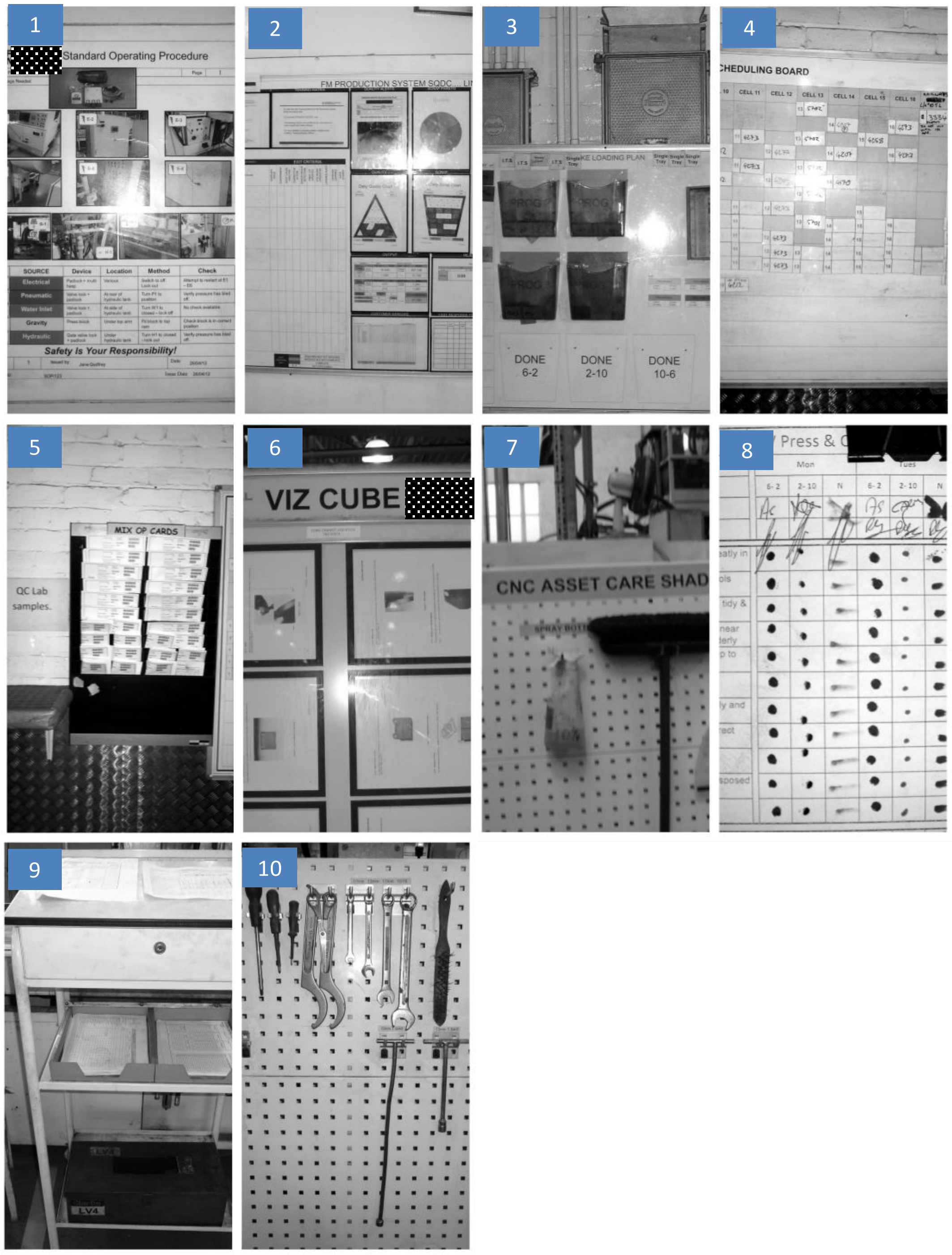


Figure 4-23 - Photographs for Questionnaire Rating

Having administered the questionnaire to all 30 respondents, in Figure 4-24 below I have shown how the data was prepared for analysis. Shown are three rows of data where the responses from one manager are compared to the responses from the three operators from the same value stream.

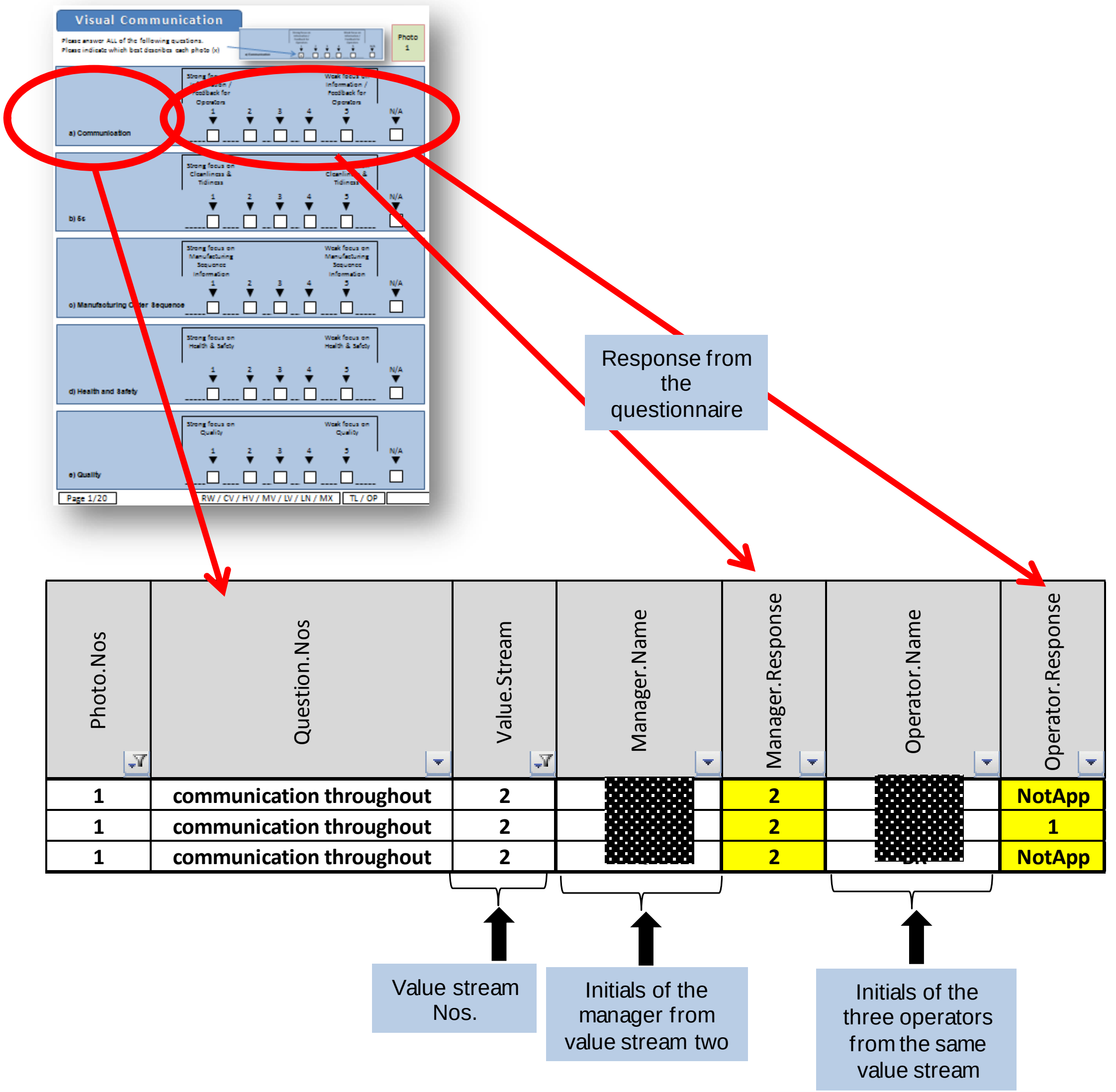


Photo.Nos	Question.Nos	Value.Stream	Manager.Name	Manager.Response	Operator.Name	Operator.Response
1	communication throughout	2	[redacted]	2	[redacted]	NotApp
1	communication throughout	2		2		1
1	communication throughout	2		2		NotApp

Figure 4-24 – Manager & Operator Rating – Photograph No. One

The survey data was summarised and presented in two way symmetrical contingency tables (McDonald et al. 1998). In Figure 4-25 below I have taken the above three responses and have represented these in the form of such a table. This table shows that where the manager gave a rating of two for a particular question, one operator rated the same question with a score of one and the remaining two operators with scores of 'N/A'.

		Operator Response					
		1	2	3	4	5	N/A
Manager Response	1						
	2	1					2
	3						
	4						
	5						
	N/A						

Figure 4-25 – Symmetrical Contingency Table of Questionnaire Data

If both the manager and operators agree about the rating to a question for a particular photograph, their responses would feature in the highlighted diagonal cells. These cells show where there is an exact match of response. In this research I only considered these exact matches (Agresti 2010), i.e. shaded diagonal cells. I further narrowed the analysis to only where there was an exact match of one or two according to the Likert scale. There are other techniques available for analysing contingency tables that have ranked ordinal data (Good 2005). However, I kept the analysis simple and visible to ensure it would be accessible to future practising managers.

A way of validating exact match data is to use Fisher's exact test (Ronald Fisher). In this research this test was done by keeping the response of the managers fixed but by seeing how many exact matches could be achieved if the responses from the operators were reordered according to every permutation. This is consistent with prioritising the managers intended meaning of the visual communication, which is in accordance with the conceptual model that privileges the message as intended by the person sending it.

The example, Figure 4-26 below, shows the results of the survey data for photograph number one. These are the responses from the two managers in this value stream compared with the three operators from the same value stream. The maximum possible number of observed ratings is given by the calculation - two managers x three operators x ten questions = sixty. Focusing only on ratings of one and two in the questionnaire there were a combined total of six times when both the managers and operators agreed about the particular rating of individual themes for photograph number one. Six observed exact matches from a potential sixty gives a result of ten percent.

Alongside this the Fisher test shows that by permuting the operator data against the manager data there were a possible sixteen counts of where one contingency table (operator versus manager table) had an exact match at a level of 1 or 2 rating, and a possible twelve counts of where two contingency tables provided matches. These, from a possible 7200 combinations (6! x 10 questions) = 0.4% potential matches from randomisation of the data. This indicates that the results from the survey are unlikely to be due to chance alone as the number of actual exact matches is many times higher than that due to random chance.

Observed Results

	Rating	Nos of Matches	Σ Matches	% Matches
Value Stream 1	#1	2	6	10%
	#2	4		
	#3	1		
	#4			
	#5	1		
	#N/A	6		
	Mis-match	46		

Random Permutations of Operators Data

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%					12	16	7172	Freq. of Matches
	6	5	4	3	2	1	0	Rating

Figure 4-26 – Exact Response Matches

In Appendix N are shown individual tables of the survey results alongside the permutation test results from the Fisher Analysis. This shows that the exact match responses obtained from the survey are unlikely to be due to chance alone.

In the following section I have explored each of the ten photographs and the correlation score of intended and interpreted meaning, ranked in order of highest correlation first. The structure of the data collection enabled the correlation of each photograph to be evaluated by individual value stream. Also using a ten questions (themed) survey enabled each of these ten questions to be assessed for their individual contribution to the overall correlation, which has helped to establish which themes were driving (or hindering) the average correlation score.

The purpose of this analysis was to demonstrate the usefulness of these research methods in establishing a baseline correlation. It also shows how this form of analysis enables access to both a headline measurement and a deeper understanding of what contributory factors drive that correlation. This is an enabling step to help managers to intervene and to make improvements in the use of visual communication.

4.2.2 Photograph Nos. Two – Shift Communication Board

The Rated Photograph - In Figure 4-27 below is shown a communications board that was part of the Automotive UK performance management system (Leeuw & Berg 2011). This board, which was repeated in each of the six value streams, had been in use at the site for several years. The managers and operators from each value stream met at the start of each shift at their respective boards to discuss the performance for their area. This shift-wise communication board was structured as "…a visual cockpit" (Bititci et al. 2016, p7) allowing the production team to monitor their key performance indicators (Bititci et al. 2016). The board, often referred to as the SQDC board (safety, quality, delivery, cost) (Suzaki 1993) was designed to be a central point of daily information. It was used to provide feedback, but also to affect control of the operators by orientating them towards the key objectives for their value stream. Based on the regularity of the shift meeting and the structured discussion of the contents of this board, a relatively high correlation measurement was seen. This relatively high rating (compared to the examples to follow) is recognition of the shared familiarity for its purpose.

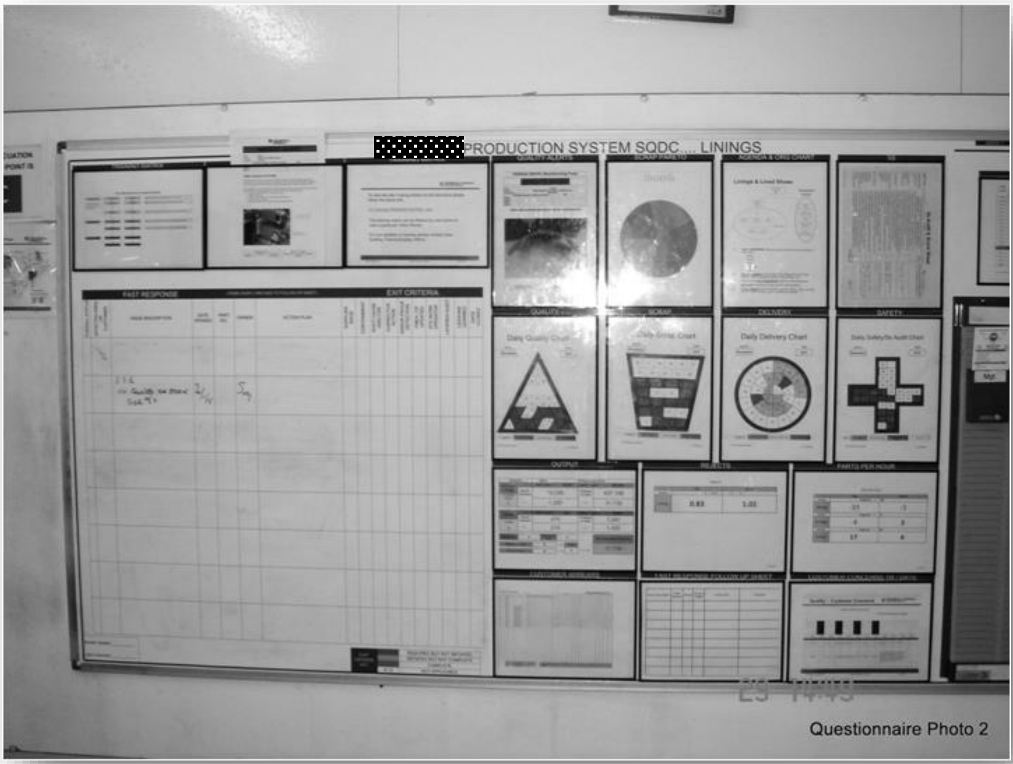


Figure 4-27 – Communication Board (1st Highest – Average of 26% Rating)

The Results – below in Figure 4-28 is the calculated effectiveness for this visual communication shown as the ratio of exact match ratings. The table shows the exact match data for each of the six value streams separately. For each of the value streams the exact match questionnaire responses (at level one and two) are highlighted. The rating calculation of 26% is established by adding together all the exact matches of one and two, i.e. 12 + 7 + 8 + 1 + 10 + 1 + 15 + 1 + 18 + 1+ 10 + 8 = 92 out of a possible 360 possible matches = 25.6%. This means, across the six value streams, 26% of the time the managers and operators rated the photograph with exactly the same score of one (strongly agreed) or two (agreed) about the meaning of this particular visual communication.

Please note that in the contingency table analysis, what is shown is only where the operator is agreeing with one and/or other of the managers from their own value stream. If the operators agree with each then this data does not feature in the table. Also if the managers agree with each other, this also does not feature in the table. The data has been arranged for analysis in this way because the aim of this research is to measure the intended meaning of visual communication by the managers versus the interpreted meaning by the operators (not operator versus operator or manager versus manager). Bearing in mind this data structure, and considering that only exact matches at a rating of one or two have been considered, a measure of 25.6% is arguably a high correlation score.

	Rating	Nos of Matches	Σ Matches	% Matches
Value Stream 1	#1	12	19	32%
	#2	7		
	#3	1		
	#4			
	#5			
	#N/A			
	Mis-match	40		
Value Stream 2	#1	8	9	15%
	#2	1		
	#3			
	#4			
	#5			
	#N/A	7		
	Mis-match	44		
Value Stream 3	#1	10	11	18%
	#2	1		
	#3	2		
	#4			
	#5			
	#N/A	6		
	Mis-match	41		
Value Stream 4	#1	15	16	27%
	#2	1		
	#3	1		
	#4			
	#5	1		
	#N/A	3		
	Mis-match	39		
Value Stream 5	#1	18	19	32%
	#2	1		
	#3			
	#4			
	#5	1		
	#N/A	2		
	Mis-match	38		
Value Stream 6	#1	10	18	30%
	#2	8		
	#3	1		
	#4			
	#5	2		
	#N/A			
	Mis-match	39		

Figure 4-28 – Communication Board (1st Highest – Average of 26% Rating)

Looking at the ten individual questions from the questionnaire and their respective exact match ratings helps to explain which themes underpin this correlation. Shown in Figure 4-29 below is the data for the theme related to 'communication throughout'. The contingency table shows 19 exact matches (score one or two) across the six value streams. The score of 19 matches is from a possible maximum score of 36, because here we are only considering one of the ten questions. This indicates a strong correlation.

Photograph Nos : **2**
Question Nos.: **Communication**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	18	3	3			
	2	5	1				
	3						
	4	5		1			
	5						
	N/A						

Figure 4-29 – Contingency Table Photograph Nos. Two - 'Communication'

A second question which also rated highly was the theme of 'production output'. Similarly across all value streams this had a score of 27 exact matches out of 36, shown in Figure 4-30 below. Again this shows a strong correlation.

Photograph Nos : **2**
Question Nos.: **Production Output**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	26	1	2	1		
	2	4	1				
	3						
	4						
	5						
	N/A						

Figure 4-30 - Contingency Table Photograph Nos. Two - 'Production Output'

A third strongly agreed upon question was the theme related to "work station quality", shown in Figure 4-31 below. It shows a score of 18 matches from a possible 36 across all value streams.

Photograph Nos : **2**
Question Nos.: **Quality**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	16	4	1			
	2	6	2	1			
	3	4	2				
	4						
	5						
	N/A						

Figure 4-31 – Contingency Table Photograph Nos. Two – 'Workstation Quality'

Finally the theme of "first aiders" was also highly rated with a score of 12 from 36 possible matches, shown in Figure 4-32 below.

Photograph Nos : **2**
Question Nos.: **Health & Safety**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	10	4	6		1	
	2	4	2	2		1	
	3	2	1				
	4	2	1				
	5						
	N/A						

Figure 4-32 – Contingency Table Photograph Nos. Two – 'Health & Safety'

Discussion – Automotive UK had invested considerable effort to standardise the design and use of this communication board (Figure 4-27). It was mandatory in all six production areas for a shift meeting to be held and to be attended by the managers and operators. This systematic implementation and use of this visual communication is likely to be the impetus that was driving the relatively higher level of correlation between intended and interpreted meaning.

Shown in Figure 4-33 below are the themes that are intended to be communicated by this board; safety, quality, delivery (production output), productivity.

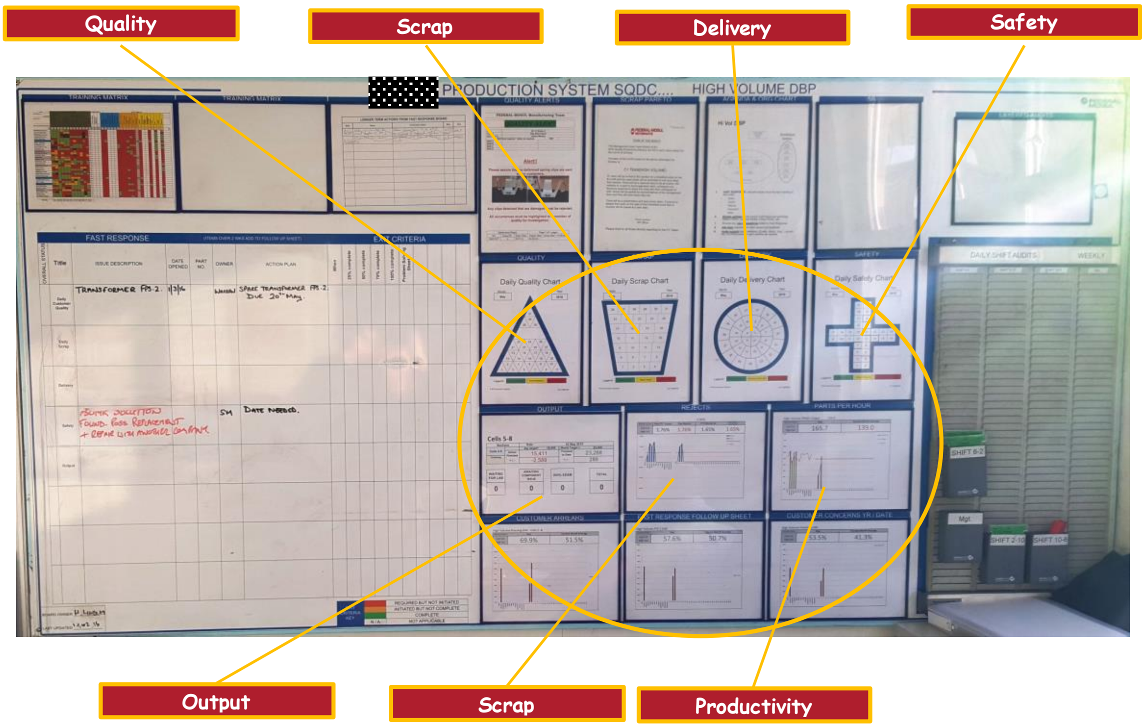


Figure 4-33 – Shift Communication Board

The themes from the questionnaire that have scored highly can be seen to be consistent with the design of the board. As part of the structured performance management system this board was reviewed by the plant manager and the functional heads each day, in each of the six production areas. The expectation can be that this would reinforce the importance of the upkeep of the boards and also a detailed awareness of its contents.

The research methods used to create the questionnaire and the stratification of the data into value streams has enabled the data to be presented and analysed using exact match contingency tables. For this first photograph this has demonstrated that the objective of measuring visual communication correlation can be achieved.

I have continued in this section to look at each of the remaining nine photographs in turn. This demonstrates the utility of the research approach and how it can be used in a practical setting. It also helps to explore the application of visual communication and highlights management practices that could affect a greater benefit from their implementation.

4.2.3 Photograph Nos. Four – Production Planning Board

The Rated Photograph - Figure 4-34 **below** shows a board that was located in value stream six (materials mixing department). It was a visual communication that was shared by all the value streams. The products prepared in this area were input materials to the remaining five value streams. Each day a meeting was held in front of this board. This meeting was attended by the manager for this area as well as the managers from each of the other five value streams. This face to face daily meeting was used to agree the schedule for production in this area, based on the demands from each of the five value streams being serviced.

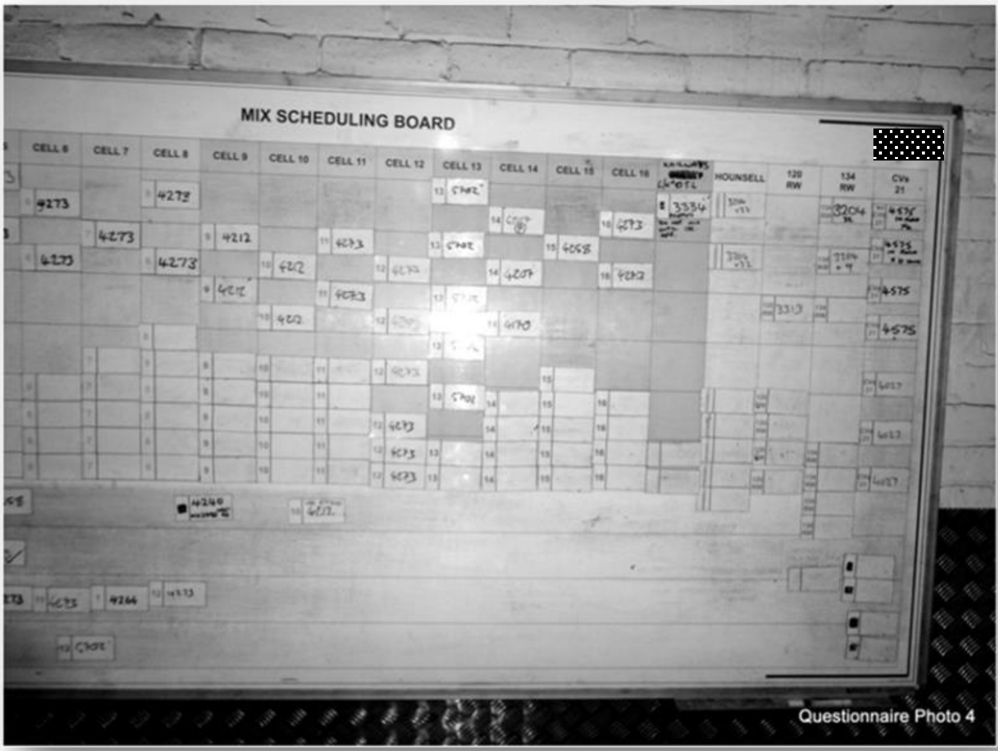


Figure 4-34 – Production Planning Board (2nd Highest – Average of 17% Rating)

The Results - Shown below in Figure 4-35 are the exact match data from each of the value streams (matched responses at level one and two). This visual communication scored the second highest with a rating of 17% average across all value streams.

	Rating	Nos of Matches	Σ Matches	% Matches
Value Stream 1	#1	6	14	23%
	#2	8		
	#3	2		
	#4			
	#5			
	#N/A	3		
	Mis-match	41		
Value Stream 2	#1	1	4	7%
	#2	3		
	#3			
	#4			
	#5			
	#N/A	9		
	Mis-match	47		
Value Stream 3	#1	9	9	15%
	#2			
	#3			
	#4			
	#5	1		
	#N/A	14		
	Mis-match	36		

	Rating	Nos of Matches	Σ Matches	% Matches
Value Stream 4	#1	10	11	18%
	#2	1		
	#3			
	#4			
	#5	4		
	#N/A	8		
	Mis-match	37		
Value Stream 5	#1	4	11	18%
	#2	7		
	#3			
	#4			
	#5	1		
	#N/A	9		
	Mis-match	39		
Value Stream 6	#1	8	12	20%
	#2	4		
	#3	2		
	#4			
	#5	1		
	#N/A	2		
	Mis-match	43		

Figure 4-35 - Production Planning Board (2nd Highest – Average of 17% Rating)

Looking at the individual questions and the ones that attracted the highest number of exact matches, the highest scoring theme for this board was in response to question 'c', “manufacturing order sequence”. This is in fact the purpose of the board and matches very closely to the title shown above the board. The details for the matched responses to this question are shown in Figure 4-36 below; 22 matches, seen in the diagonal highlighted boxes at level one and two, from a possible 36 responses.

Photograph Nos : **4**
Question Nos.: **Manufacturing Order Sequence**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	19	7				1
	2	2	3				1
	3						
	4	3					
	5						
	N/A						

Figure 4-36 - Contingency Table Photograph Nos. Four - ‘Manufacturing Order Sequence’

Discussion - As a visual communication that was shared by the managers across the different value streams, it could be expected that there would be a clear understanding of its purpose. However, because the board is not generally shared at the operator level then they could be expected to be less familiar with it, and I would have expected a generally low level of exact matches in the contingency table. It was apparent however during the administration of the questionnaire that there was a widespread understanding about its intended purpose. The results table shows a strong level of exact match responses from each of the six value streams.

The reason for this could be that the design of the board, with a very visible and clear title, has helped to achieve the relatively high score. The board title was easily legible in the photograph used during the questionnaire, and has perhaps helped to support the process of recognition, despite operators not necessarily being directly familiar with the board or its location. The results from this analysis have indicated that a well designed title for a visual communication could be important in enabling an alignment between intended and received message.

4.2.4 Photograph Nos. One – Machine Isolation Procedure

The Rated Photograph - The photograph below (Figure 4-37) shows a machine isolation procedure. This document describes the protocol for safely disconnecting the machine from energy sources, and was normally used when the machine was being cleaned or repaired. This photograph is specifically related to value stream number two.

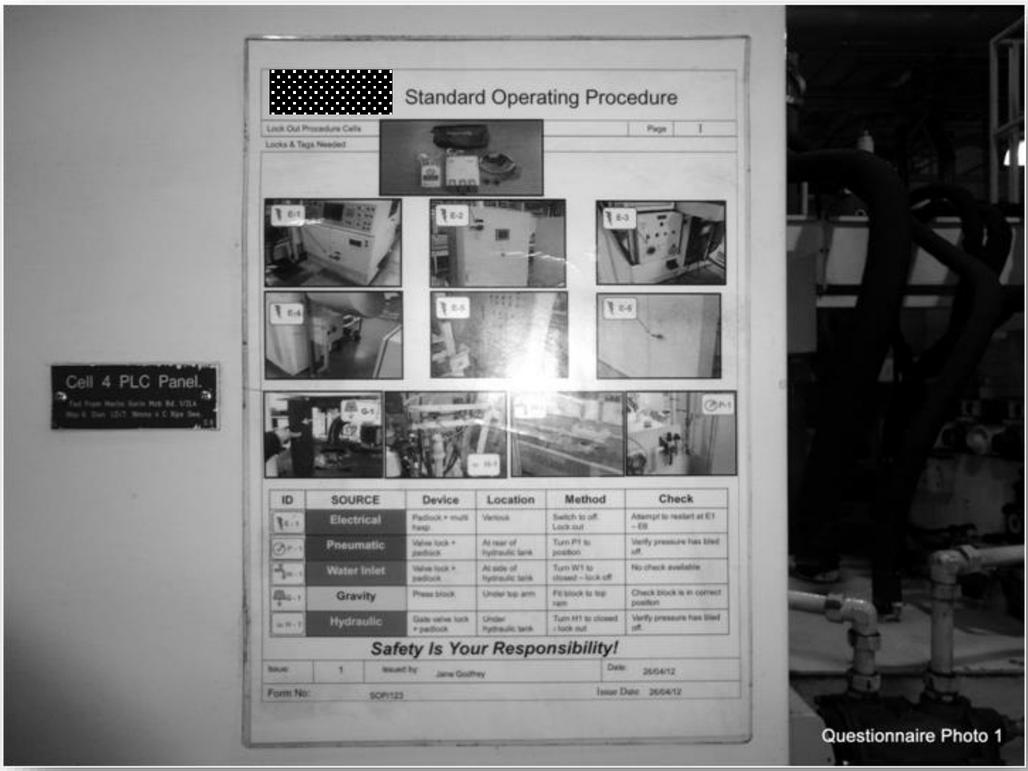


Figure 4-37 – Machine Isolation Procedure (3rd Highest – Average of 15% Rating)

The Results - Shown below in Figure 4-38 are the exact match data for each of the value streams (matched responses at level of one and two). This visual communication scored the third highest result in terms of visual communication correlation. The score was 15% across the six value streams.

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches
Value Stream 1	#1	2	6	10%
	#2	4		
	#3	1		
	#4			
	#5	1		
	#N/A	6		
	Mis-match	46		
Value Stream 2	#1	5	5	8%
	#2			
	#3			
	#4			
	#5			
	#N/A	17		
	Mis-match	38		
Value Stream 3	#1	11	11	18%
	#2			
	#3	4		
	#4			
	#5			
	#N/A	3		
	Mis-match	42		
Value Stream 4	#1	15	16	27%
	#2	1		
	#3	2		
	#4			
	#5	2		
	#N/A			
	Mis-match	40		
Value Stream 5	#1		6	10%
	#2	6		
	#3			
	#4	1		
	#5	4		
	#N/A	3		
	Mis-match	46		
Value Stream 6	#1	9	10	17%
	#2	1		
	#3	2		
	#4			
	#5			
	#N/A			
	Mis-match	48		

Figure 4-38 - Machine Isolation Procedure (3rd Highest – Average of 15% Rating)

Discussion - Despite this isolation procedure being specifically displayed in value stream number two, the results indicated that other value stream team members also understood its intended meaning. There were at least two explanations for this. The first reason was that the title stated this was a ‘standard operating procedure’. This was a term familiar to both operators and managers. This reinforces the findings in the discussion relating to photograph number four (production planning board) where a clear title has possibly helped to give a clear message about the purpose of the visual communication. The second reason was that the procedure was related to the method for safely isolating a machine tool. The operators and managers are both trained to be familiar with the need and use of such ‘isolation procedures’.

Different value streams, due to the variety of products that they produce, are expected to do more or less changeovers. For example, value stream four and six have the highest number of changeovers. Value stream three has relatively fewer and value stream two has relatively fewer still. It is interesting that the exact matches also follow this general pattern, indicating a possible linkage of visual communication correlation with the familiarity through usage.

4.2.5 Photograph Nos. Eight – Operator Checklist

The Rated Photograph - The photograph shown in Figure 4-39 below is of a document which is located in the working area of the operators. It is a check-sheet to remind the operators of machine checks and cleaning duties they are responsible for. The purpose of this is to ensure that the work place remains organised for this and subsequent shifts. This document is standardised across all six value streams. It is filled in each shift by the operators. It is then signed by the operator and counter-signed by their manager.

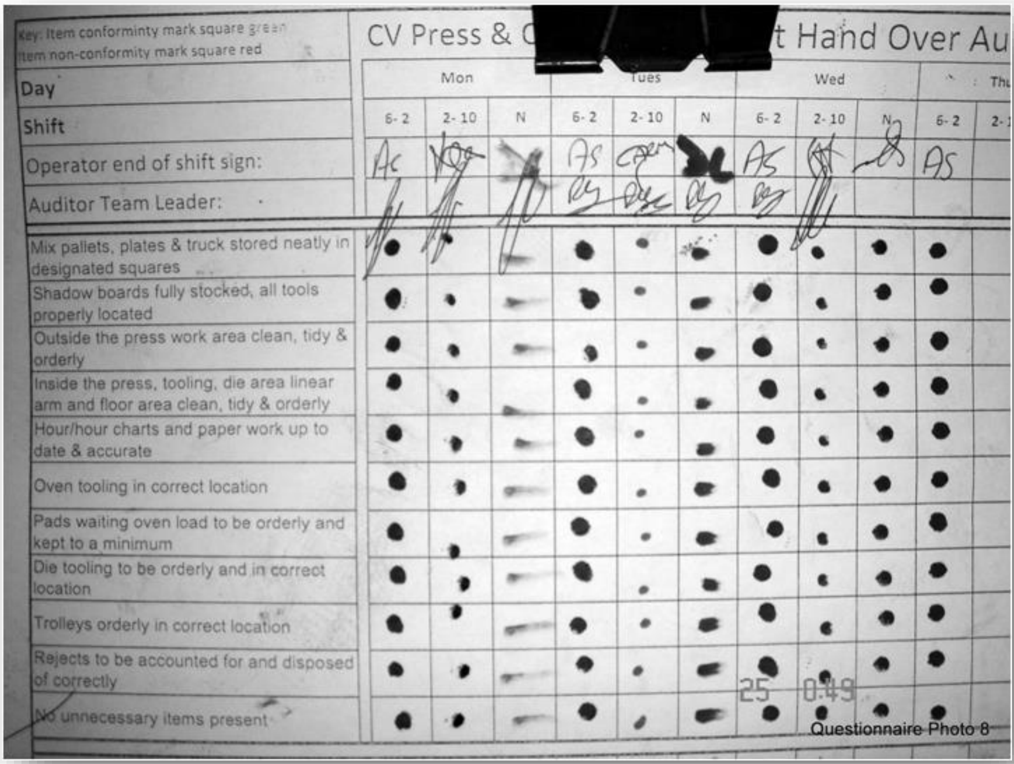


Figure 4-39 – Operator Checklist (4th Highest – Average of 14% Rating)

The Results - Shown below in Figure 4-40 are the exact match data for this photograph. This visual communication scored the fourth highest with a score of 14% across all the value streams.

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches
Value Stream 1	#1	4	10	17%
	#2	6		
	#3	3		
	#4			
	#5	2		
	#N/A	0		
	Mis-match	45		
Value Stream 2	#1	2	3	5%
	#2	1		
	#3			
	#4			
	#5			
	#N/A	19		
	Mis-match	38		
Value Stream 3	#1	10	11	18%
	#2	1		
	#3	3		
	#4			
	#5			
	#N/A	11		
	Mis-match	35		
Value Stream 4	#1	14	16	27%
	#2	2		
	#3			
	#4	1		
	#5	2		
	#N/A	3		
	Mis-match	38		
Value Stream 5	#1	5	6	10%
	#2	1		
	#3	1		
	#4			
	#5	3		
	#N/A	6		
	Mis-match	44		
Value Stream 6	#1	4	6	10%
	#2	2		
	#3	4		
	#4	2		
	#5			
	#N/A	5		
	Mis-match	43		

Figure 4-40 - Operator Checklist (4th Highest – Average of 14% Rating)

The questions where this visual communication scored the highest number of exact matches was for the theme related to cleanliness and tidiness, i.e. question 'b' in the questionnaire. This had 22 exact matches, shown below in Figure 4-41. In this table, the term 5s has been used. The terms 5s refers to a Lean tool utilised to arrive at solutions to create a workplace that is organised and orderly (Liker 2003).

Photograph Nos : **8**
Question Nos.: **5s**
Value Stream Nos : **ALL**

Manager Response	**Operator Response** 1	2	3	4	5	N/A
1	22	1	1			
2	5		1			
3	2	1				
4						
5	3					
N/A						

Figure 4-41 - Contingency Table Photograph Nos. Eight 'Dusty and Dirty'

Discussion - There was seen to be a familiarity with this document across the value streams which stemmed from its standardised use. That its purpose was clearly understood is indicated by the high number of exact matches related to the theme of 5s, i.e. cleaning standards. This was another example where regular reinforcing of the standard seemed to have resulted in a high level of agreement about the meaning of a specific visual communication. This reinforcement was partly enforced by the counter signature of the manager, which as a validation check, ensured that the operators had complied with the requirements of the respective procedures.

4.2.6 <u>Photograph Nos. Six – Quality Standards Board</u>

The Rated Photograph - The photograph shown below in Figure 4-42 is of a rotating display tower which has documents displayed on each of its four sides. The documents illustrated different types of quality defects relating to the products being produced. This tower was repeated in each of the six different value streams.

<u>Figure 4-42 – Quality Standards Board (5th Highest – Average of 11% Rating)</u>

The Results - Shown below in Figure 4-43 is the exact match data for this photograph. This visual communication scored the fifth highest with 11% across all the value streams.

	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 1	#1	4	19	32%
	#2	15		
	#3	2		
	#4			
	#5			
	#N/A			
	Mis-match	39		
Value Stream 2	#1	2	3	5%
	#2	1		
	#3	2		
	#4	1		
	#5	2		
	#N/A			
	Mis-match	52		
Value Stream 3	#1		0	0%
	#2			
	#3	1		
	#4			
	#5	1		
	#N/A	19		
	Mis-match	39		
Value Stream 4	#1	9	11	18%
	#2	2		
	#3	1		
	#4			
	#5			
	#N/A	5		
	Mis-match	43		
Value Stream 5	#1		1	2%
	#2	1		
	#3			
	#4			
	#5	4		
	#N/A	5		
	Mis-match	50		
Value Stream 6	#1	3	6	10%
	#2	3		
	#3	6		
	#4	2		
	#5			
	#N/A			
	Mis-match	46		

Figure 4-43 - Quality Standards Board (5th Highest – Average of 11% Rating)

This photograph gave a fragmented correlation result. The low average score is partially explained by the comments expressed by the managers and operators about the lack of clarity about its motivation and use. Some of the comments from different areas included:

> "Don't like them. Not being used...should be good communication but not practically being used...never seen anyone looking at it"
>
> (Manager – value stream number three)
>
> "Good idea….not sure who implemented them"
>
> (Manager – value stream number one)
>
> "Really not clear...going up or down?...Have to study it. Not immediately clear what it is"

(Manager – value stream three)

"Pictures are sideways"

(Operator – value stream number six)

However despite the ambiguity regarding this visual communication, theme 'e' ('quality') was still rated the highest with 12 matches at a level of one or two, from a potential of 36, seen in Figure 4-44 below.

Photograph Nos : **6**
Question Nos.: **Quality**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	9	3				
	2	17	3	1			
	3			1			
	4	2					
	5						
	N/A						

Figure 4-44 - Contingency Table Photograph Nos. Six – 'Quality'

The second highest scoring was theme 'a' ('communication') with nine matches from 36, see Figure 4-45 below.

Photograph Nos : **6**
Question Nos.: **Communication**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	7	4				1
	2	8	2	1			1
	3	4	1	1			
	4	2	1				
	5	3					
	N/A						

Figure 4-45 - Contingency Table Photograph Nos. Six – 'Communication'

Discussion - This photograph exhibits issues of communication problems. It is a communication that is seemingly overwhelmed with 'noise' that has resulted in dispersed data. Despite this the research methods have enabled access to the overall correlation of the communication and are sensitive enough to drill down to the themes themselves to see which areas are underpinning (or undermining) the headline rating.

This communication was intended to be informative to the operators, but from the comments made during the data collection it seemed that there had not been sufficient associated training in their usage, or insistence (through auditing etc.) that they be used. It was not a communication that the operators engaged with on a daily basis so there seemed to be a general lack of familiarity with its purpose. In addition the title was ambiguous in that it stated 'viz cube' but did not explicitly state that this was a quality related communication board.

4.2.7 <u>Photograph Nos. Ten – Operator Work Station</u>

The Rated Photograph - Photograph ten shown in Figure 4-46 below is of a table that was placed next to a machine in one of the value streams. It was intended for use by the operator as a place to store and fill-in various documents that were being completed during the shift. Additionally it had a bottom shelf to locate a scrap bin where defective components that were detected at this process could be quarantined.

Figure 4-46 – Operator Work Station (6th Highest – Average of 9% Rating)

The Results - Shown below in Figure 4-47 is the exact match data for this photograph. This visual communication scored the joint sixth highest with an efficiency score of 9% across all the value streams.

	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 1	#1	5	13	22%
	#2	8		
	#3	2		
	#4	2		
	#5			
	#N/A			
	Mis-match	43		
Value Stream 2	#1		2	3%
	#2	2		
	#3			
	#4			
	#5			
	#N/A	6		
	Mis-match	52		
Value Stream 3	#1	3	3	5%
	#2			
	#3	1		
	#4			
	#5	3		
	#N/A	10		
	Mis-match	43		
Value Stream 4	#1	7	8	13%
	#2	1		
	#3	2		
	#4	2		
	#5			
	#N/A	3		
	Mis-match	45		
Value Stream 5	#1	0	1	2%
	#2	1		
	#3	1		
	#4	1		
	#5	4		
	#N/A	1		
	Mis-match	52		
Value Stream 6	#1		7	12%
	#2	7		
	#3	2		
	#4			
	#5			
	#N/A			
	Mis-match	51		

Figure 4-47 - Operator Work Station (6th Highest – Average of 9% Rating)

This visual communication achieved only a relatively low overall score. This table (shown in the above photograph - Figure 4-46) was increasingly standardised across the six value streams, and during the data collection my perception was that the photograph was quickly recognised, and the purpose of the table was familiar. However, despite this the overall rating score was relatively low. The themes in order of matches were:

- Theme 'a' - 'Communication' - scoring seven matches,
- Theme 'h' - 'Measurement and recording' - scoring six matches,
- Theme 'j' - 'Production output'- also scoring six matches,
- Theme 'e' - 'Quality' scored five exact matches.

Discussion - The issue here did not seem to be a lack of recognition of the purpose of the visual communication. The table was used for a variety of purposes and all of these were identified by the analysis and were clearly associated with this table by the managers and operators. However, it seemed that due to its multiple uses there was also a lower clear focus that could be agreed upon in terms of the questionnaire.

The table had a lack of descriptive visual labels attached to it to identify its purpose. Based on the findings for photographs one, four and six above, it seems that clear visual titles to match the intended purpose could help to improve the correlation of how well the intention of this table is communicated.

These findings also suggest that visual communication is more clearly interpreted when it is motivated by a specific single theme. Perhaps multiple themes within visual communication are seen as being efficient by those creating them, however, there seems to be a risk of different recipients seeing only some and not all of what was intended (Jensen 2016).

4.2.8 <u>Photograph Nos. Five – Works Order Storage Rack</u>

The Rated Photograph - Photograph five (see Figure 4-48 below) shows a board that was located within value stream six. It is of a rack where production orders referred to as 'works orders', were being stored. These are the documents released by the production planning department that authorise the shop-floor to produce a particular type and quantity of product.

Figure 4-48 – Works Order Storage Rack (Joint 6th Highest – Average of 9% Rating)

The Results - Shown below in Figure 4-49 are the exact match data for this photograph. This visual communication scored the joint sixth highest with a score of 9% across all the value streams.

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 1	#1		20	33%
	#2	20		
	#3	1		
	#4			
	#5			
	#N/A	3		
	Mis-match	36		

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 2	#1	1	1	2%
	#2			
	#3			
	#4			
	#5			
	#N/A	18		
	Mis-match	41		

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 3	#1	2	5	8%
	#2	3		
	#3	1		
	#4			
	#5	1		
	#N/A	10		
	Mis-match	43		

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 4	#1	5	5	8%
	#2			
	#3			
	#4			
	#5	4		
	#N/A	7		
	Mis-match	44		

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 5	#1	1	3	5%
	#2	2		
	#3			
	#4	1		
	#5			
	#N/A	9		
	Mis-match	47		

Value Stream	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 6	#1		0	0%
	#2			
	#3	3		
	#4	4		
	#5	2		
	#N/A			
	Mis-match	51		

Figure 4-49- Works Order Storage Rack (Joint 6th Highest – Average of 9% Rating)

What was unusual with this visual communication was that the value stream where the board is used daily (value stream six) was the only area to have no exact matches whereas the other areas had up to 20 exact matches (33% from value stream number one). For those operating 'inside' the area where the board is located, one manager gave it a score of four and the other a score of five to say that it is very weakly related to the theme of manufacturing order sequence. It transpired that what at first glance looked like some form of scheduling system was instead being used as a storage rack for other documents. The comments made by one of the managers from this area were:

"just a storage location for cards...nothing to do with sequencing of production".

The contingency table above shows that there were 34 matched responses (level one or two) from areas outside where this visual communication was located, i.e. exact matches from areas other than value stream six. As can be seen in the four tables in Figure 4-50 below, 24 of the 34 matches were related to production scheduling/planning and quality related issues. This was consistent with the labelling shown in the photograph but was not consistent with its current usage.

Photograph Nos : **5**
Question Nos.: **Manufacturing Order Sequence**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	3		1		1	1
	2	9	2	1			
	3	5		1		2	1
	4	1	1				1
	5	2	1	1		1	1
	N/A						

Photograph Nos : **5**
Question Nos.: **Set-Up Information**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**		2				1
	2		5	1		1	2
	3		4	1		1	
	4		3			1	2
	5		4			1	4
	N/A						3

Photograph Nos : **5**
Question Nos.: **Process Control**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	2	1			1	2
	2	2	4				
	3			1			5
	4	1	3		1		1
	5	1	2	1	1	1	6
	N/A						

Photograph Nos : **5**
Question Nos.: **Production Output**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	2		3			1
	2		6				
	3	1		1			4
	4		1		1		4
	5	1	3	2	1		2
	N/A		2				1

Figure 4-50 – Contingency Tables Photograph Nos. Five – Non-Value Stream Scores

Discussion - The overall low score from this area seemed to be due to the contradiction between the title of the board, "mix op cards" and "QC Lab samples", and the documents actually being stored there. It seemed that managers and operators from other value streams had read the title of the board (seen in photograph number five, Figure 4-48) and had taken this at face value, incorrectly assuming it was some form of scheduling system.

This further reinforces the earlier findings that a simple clear title can orientate individuals to the meaning of visual communication, and it seems that it can make the difference between understanding and confusion. The results suggest the importance of housekeeping in relation to visual communication, as redundant labels served to confuse those within and outside the value stream area.

4.2.9 Photograph Nos. Seven – Shadow Board

The Rated Photograph - Figure 4-51 below shows a shadow board used for storing cleaning equipment. The use of shadow boards, where a painted outline of the article is used to indicate what is to be stored in that location / position, is typical of marking storage areas in manufacturing environments (Suzaki 1993, Greif 1991). The function of the shadow board is intended to help ensure that at a glance an operator can see where an item is located, or if it is missing.

Figure 4-51 – Shadow Board (8th Highest – Average of 8.3% Rating)

The Results - Shown below in Figure 4-52 are the exact match data for this photograph. This visual communication scored the eight highest with a score of 8.3% across all the value streams.

Value Stream	Rating	Nos of Matches	∑ Matches	% Matches from 60 questions
Value Stream 1	#1	5	7	12%
	#2	2		
	#3	3		
	#4			
	#5	1		
	#N/A			
	Mis-match	48		
Value Stream 2	#1	3	3	5%
	#2			
	#3			
	#4	1		
	#5			
	#N/A	18		
	Mis-match	38		
Value Stream 3	#1	3	3	5%
	#2			
	#3			
	#4			
	#5			
	#N/A	23		
	Mis-match	34		

Value Stream	Rating	Nos of Matches	∑ Matches	% Matches from 60 questions
Value Stream 4	#1	6	6	10%
	#2			
	#3	2		
	#4			
	#5	1		
	#N/A	17		
	Mis-match	34		
Value Stream 5	#1	7	7	12%
	#2			
	#3			
	#4			
	#5	1		
	#N/A	25		
	Mis-match	27		
Value Stream 6	#1	4	4	7%
	#2			
	#3	1		
	#4	1		
	#5			
	#N/A	2		
	Mis-match	52		

Figure 4-52 - Shadow Board (8th Highest – Average of 8% Rating)

Although this photograph had only the 8th highest correlation rating, during the administration of the questionnaire the comments suggested that it was clear that both managers and operators knew the purpose of this visual communication.

Studying the data for the individual themes indicates that this visual communication was in fact well understood. Question ‘b’ which is related to cleaning standards, i.e. ‘5s’, scored 26 matches from a possible 36. This is shown below in Figure 4-53. The exact match data indicates that there was a clear understanding that this visual communication was related to workplace organisation and cleanliness.

Photograph Nos : **7**
Question Nos.: **5s**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	26	2		2		
	2	3					
	3	3					
	4						
	5						
	N/A						

Figure 4-53 - Contingency Table Photograph Nos. Seven - '5s'

Discussion – If in this analysis only exact matches at level one in the contingency table were considered then this board would be rated higher than eighth position. The data shows that there was a clear understanding of the purpose of this board by those in the organisation, which was evident during the administration of the questionnaire. The inclusion in this analysis of exact matches at a level two has helped to prioritise other, less strongly focussed visual communication. As mentioned earlier, I have purposely avoided looking at ranked ordinal scales (Good 2005) to simplify the analysis of the data. This more basic approach retains the practical applicability of this method but makes it necessary to also look at the exact matches data for individual themes (as I have shown above in Figure 4-53) to understand the components of the final rating.

4.2.10 Photograph Nos. Three – Order Planning Board

The Rated Photograph – Photograph three shown in Figure 4-54 below is of a production planning board that was located inside a manufacturing cell within value stream number five. In practice only the extreme left hand side of the board (first eight columns) were being used. The right hand side was now redundant but the additional unnecessary document holders and labels on the board had not been removed.

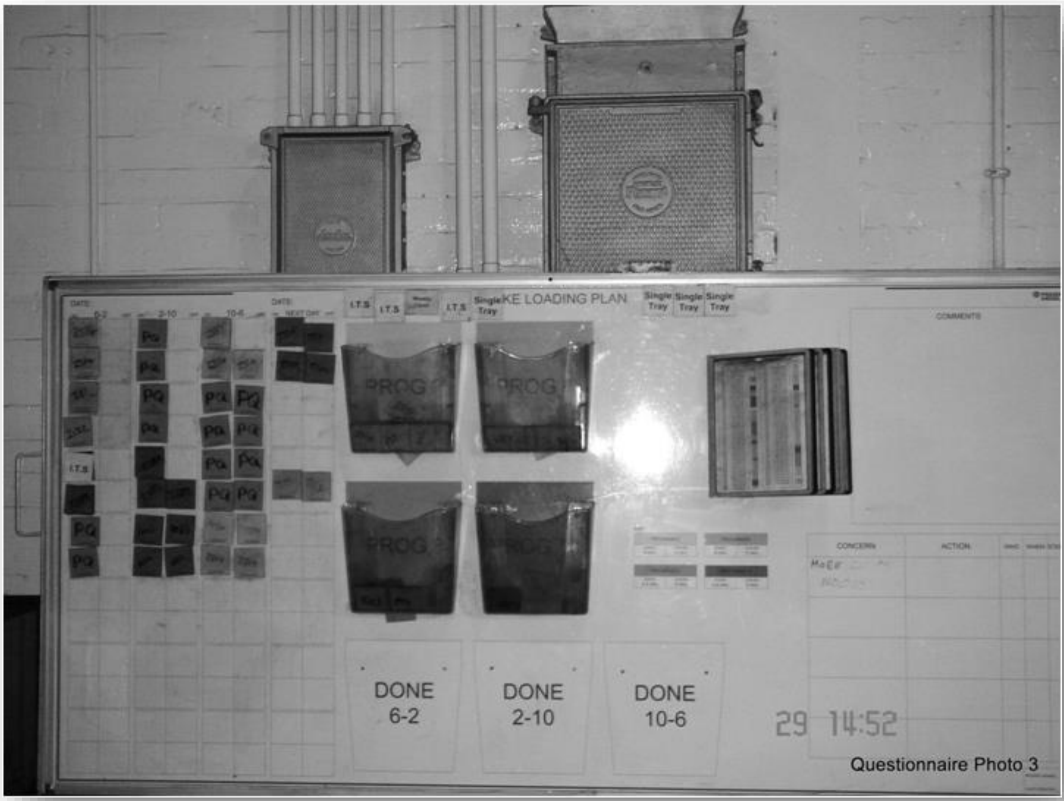


Figure 4-54 – Order Planning Board (9th Highest – Average of 7.5% Rating)

The Results - Shown below in Figure 4-55 are the exact match data for this visual communication. This scored the ninth highest with 7.5% across all the value streams.

Value Stream 1	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
	#1		0	0%
	#2			
	#3			
	#4	1		
	#5			
	#N/A	1		
	Mis-match	58		

Value Stream 2	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
	#1	1	1	2%
	#2			
	#3			
	#4	1		
	#5	3		
	#N/A	2		
	Mis-match	53		

Value Stream 3	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
	#1		3	5%
	#2	3		
	#3	1		
	#4	1		
	#5	2		
	#N/A	12		
	Mis-match	41		

Value Stream 4	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
	#1	6	9	15%
	#2	3		
	#3			
	#4			
	#5	3		
	#N/A	6		
	Mis-match	42		

Value Stream 5	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
	#1	7	9	15%
	#2	2		
	#3			
	#4			
	#5			
	#N/A	8		
	Mis-match	43		

Value Stream 6	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
	#1	3	5	8%
	#2	2		
	#3	2		
	#4			
	#5			
	#N/A			
	Mis-match	53		

Figure 4-55 - Order Planning Board (9th Highest – Average of 7.5% Rating)

The correlation of this board was rated lower by value streams one, two and three but higher by value streams four and six. This visual communication is located within value stream five and is designed to be used internally only by that value stream.

Discussion - It is possible that the higher scores from some of the value streams were associated with where the respondents to the questionnaire had compared this board to other boards they were familiar with and had guessed what it was related to. The recorded comments from the managers and operators during the questionnaire provide some evidence of a generally confused meaning for this visual communication, i.e.

> "Not clear what the folder type document is about"
>
> (Manager – value stream number three).
>
> "Not clear how board works..not from this area"

(Manager – value stream number three).

"Not clear visuals. Looks like 10-6 shift have no work"

(Manager – value stream number one).

"Board in front of electrical panels...so H&S is poor"

(Manager – value stream number one).

The issue here again seemed to relate to what amounted to a very 'noisy' visual communication. It was seemingly interpreted correctly by those it was aimed at because of their familiarity with its use and context. It could be that this familiarity is what has compensated for what was a relatively ambiguous message. It would however have been problematic for new comers to the area to grasp its meaning. The issues of contextual awareness compensating for ‘noisy’ communication signals (Fiske 2011) as well as other related aspects of the communication processes are discussed in the next chapter.

4.2.11 Photograph Nos. Nine – Tooling Shadow Board

The Rated Photograph – The visual communication shown in Figure 4-56 below is of a tooling storage board located within value stream four. Its purpose was very similar to that shown in photograph seven discussed earlier. The key difference was that this board did not have an overall title or labelling to indicate which tooling was to be stored in which location.

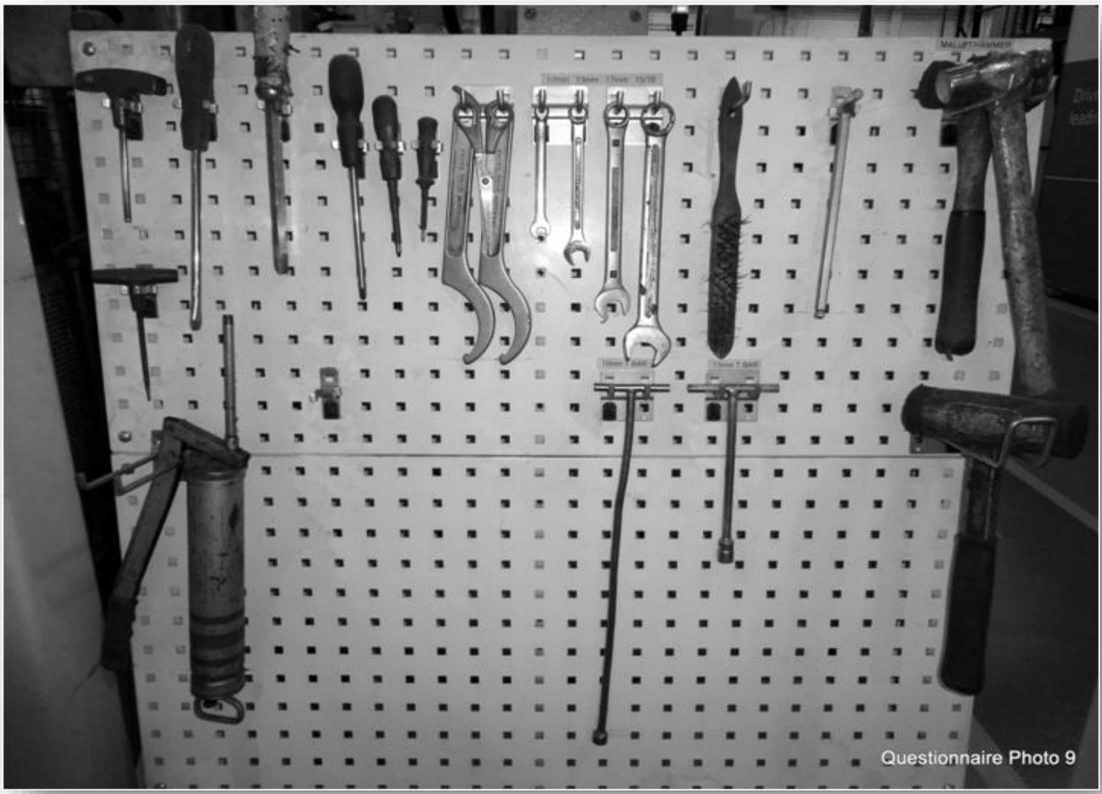


Figure 4-56 – Tooling Shadow Board (10th Highest – Average of 7% Rating)

The Results - Shown below in Figure 4-57 are the exact match data for this photograph. This visual communication scored the tenth highest with 7% across all the value streams.

	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 1	#1		19	32%
	#2	19		
	#3			
	#4			
	#5	2		
	#N/A	1		
	Mis-match	38		
Value Stream 2	#1	1	1	2%
	#2			
	#3			
	#4			
	#5			
	#N/A	24		
	Mis-match	35		
Value Stream 3	#1		0	0%
	#2			
	#3			
	#4			
	#5			
	#N/A	20		
	Mis-match	40		

	Rating	Nos of Matches	Σ Matches	% Matches from 60 questions
Value Stream 4	#1		0	0%
	#2			
	#3			
	#4			
	#5	5		
	#N/A	12		
	Mis-match	43		
Value Stream 5	#1		0	0%
	#2			
	#3			
	#4			
	#5	4		
	#N/A	18		
	Mis-match	38		
Value Stream 6	#1	1	4	7%
	#2	3		
	#3	1		
	#4	2		
	#5			
	#N/A	4		
	Mis-match	49		

Figure 4-57 - Tooling Shadow Board (10th Highest - 7% Rating)

Theme 'b' which is associated with cleanliness, shown below in Figure 4-58, had six exact matches. This was the highest number of exact matches for any of the ten themes for this photograph.

Photograph Nos : **9**
Question Nos.: **5s**
Value Steam Nos : **ALL**

		Operator Response					
		1	**2**	**3**	**4**	**5**	**N/A**
Manager Response	**1**	1	7				1
	2	3	5			1	
	3	6	7			1	1
	4						
	5	2	1				
	N/A						

Figure 4-58 - Contingency Table Photograph Nos. Nine – ALL Themes

Discussion - This board, similar to that shown in photograph number seven, was being used as a shadow board (Suzaki 1993, Greif 1991). However, in contrast to that board, this board was poorly labelled. There was no title on the board and there were no labels against each location for the tooling. Also there were no shadows outlined on the board to indicate which tool was to be stored in which location. This seemed to create some confusion as to its exact purpose. This lack of clarity can be seen in the contingency table above (Figure 4-58). For the 5s theme, it shows that the responses from the managers and operators are relatively dispersed, although there is congregation of matches close to a response level of one which indicates that overall there was some agreement that this visual communication was related to cleanliness ('5s'). This again points to the potential benefits of using ranked ordinal data (Good 2005) analysis to determine the overall visual communication correlation.

This concludes the exploration of each of the ten photographs and the respective correlation scores, and shows the utility of the research methods to access the intended and interpreted meanings.

4.2.12 Summary of Questionnaire Analysis

The second objective of this research was to establish the effectiveness of visual communication by comparing the intended meaning by managers with the interpreted meaning by operators.

The creation and administering of the questionnaire, based on the psychological constructs of the managers, has enabled this research to correlate the interpretation of a number of visual communication examples. I have presented, above, the results of having administered this questionnaire to the managers and operators and have then compared the results. I have shown how exact match contingency tables, focussing only on matches at a level of one or two, can be used to access the effectiveness of visual communication. I have further shown how exact match tables can be used to explore the data for each of the photographs at a theme by theme level, and how this can be used to enhance our understanding of the way in which visual communication is being used.

Using this measurement tool on ten examples of visual communication from Automotive UK has provided some useful insights into the use of visual communication and some best practice lessons learnt. Having determined and organised the photographs from highest intended to interpreted correlation rating to lowest rating, a general pattern has emerged. This can be described as consisting three groups of effectiveness.

The first group consist of visual communication with the strongest correlations. These are the ones where the communication has been standardised across the plant; being used in several if not all value streams. Those visual communications that had a standardised site wide design, and were used regularly in accordance with organisation policy, tended towards the higher ratings of correlation. They tended to be better designed in respect of good strong titles and labelling, and also in terms of insistence by managers that they be used. For example photograph two, showing the 'shift communication board', scored highly in terms of rating matches. This was despite it being a complex example of communication with many different elements.

The second group consisted of communication that had the weakest rating. These were typically being used only within individual value streams. They were often designed informally, and were not as well managed from a visual communication perspective in terms of clear titles, labelling, training, and insistence in their use.

The third group consisted of those that had a somewhere in-between rating of the other two groups. These visual communications were both from across and within value streams. These tended to suffer from some strengths and some weakness from the visual communication at either end of the scale. In this group the labelling was somewhat ambiguous or missing, causing the communication to sometimes be incorrectly identified. This misinterpretation was typically by those that were from outside the particular value stream where these communication were situated, so were unaware of its usage context.

The key findings are that clear unambiguous titles as headings to the visual communication seemed to help improve the effectiveness. This was demonstrated by several examples in both a positive and a negative way, i.e.

greater agreement was reached when there were clear titles about the visual communication. However, if the title was misleading, then those unfamiliar with the visual communication would take the title at face value and assume it was accurate.

Beyond the title it seemed important that labels, or other identifiers, i.e. silhouettes on the shadow boards, were also useful to identify elements of the visual communication and improve their effectiveness. Where these were missing there was more opportunity for misalignment in intended and interpreted meaning.

The usage of visual communication within the value streams often seemed reliant on contextual knowledge by the managers and operators to make up for shortfalls in their visual design. It seemed that generally less care was taken for internal visual communication than those that were expected to be shared with outsiders to the value stream. It may be that the social context can bridge the gap in poor design in this particular type of environment because of its slow to change character with overall relatively few key imperatives, but this may become dysfunctional in alternative, more dynamic environments. The key learning point was that to positively affect the effectiveness it was important to have well designed visual communication, which was well implemented, through good choice of location and training, followed by clear enforced policies about how they were used.

4.3 Visual Communication & Hierarchy

In the next section and final part of this chapter I have briefly highlighted some tentative findings from the pilot study. The purpose of conducting the pilot study was to test the research methods. However, having completed this research, I was interested to compare and contrast the themes that were elicited by the supervisor during the pilot study with those themes from the managers. The primary reason for conducting this comparison was based on the assertion that those at different levels of the hierarchy have different needs for communication (Jaques 1990) within the context of performance management systems (Lee & Dale 1998, Bititci et al. 1997). I expected to find some evidence of different themes emerging from the supervisor and managers. However I acknowledge that having data from a single supervisor could be misleading.

At Automotive UK the operators and managers formed two respective hierarchical levels. Only one of the value streams had the additional hierarchical level directly above the manager, referred to as a supervisor (see Figure 3-7 for a representative organisational chart and explanation). Both were considered as being shop-floor based, with both the managers and supervisor having offices adjacent to the physical value streams.

In Figure 4-59 below I have compared the resulting themes from the supervisor and manager's photo-elicitation and ECRS activity. Gaps between the two are highlighted with the shaded boxes. I have briefly explored these below.

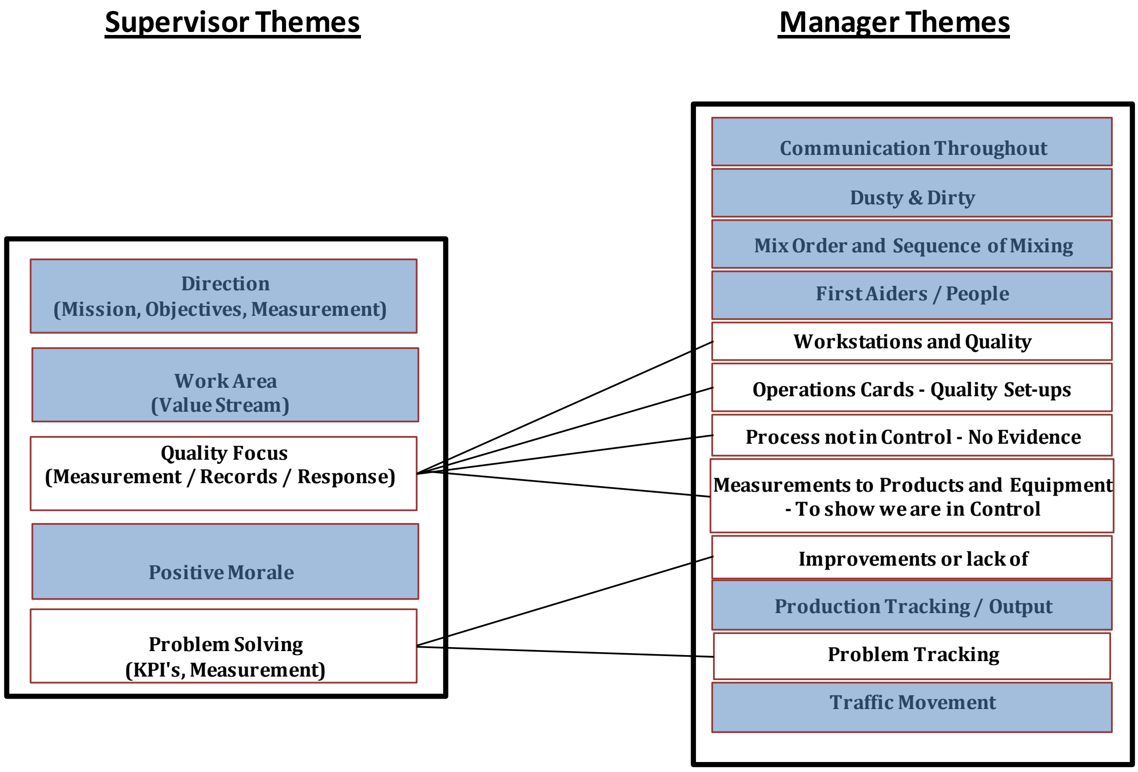


Figure 4-59 – Comparison of Themes - Supervisor & Managers

The first difference between the two sets of themes was "direction - mission, objectives, measurement". This had been was identified by the supervisor but not the managers. During the photo-elicitation, the supervisor identified a link between the mission statement and the cascaded key-performance-indicators (KPI's) used as targets within the value stream. In contrast, the managers' comments were related to their cascaded shift-wise goals in the form of KPI's. They did not make any reference to a connection between their goals and the overall company level mission/vision. Generally the supervisor seemed more aware of the connectivity between mission statement and the cascaded linkages to objectives and KPI’s.

A second difference in elicited themes was “work area” (value streams) (Liker 2003). In contrast to the supervisor’s responsibilities, the managers within the value streams were normally only responsible for their own areas and were very rarely asked to assume any responsibility for other areas. In contrast however the supervisor also worked on a night shift rota. During the night shift the supervisor assumed responsibility for the whole shop-floor (all six value streams) as opposed to only this production area. This was a job classified as "night watch-man duty". Practically this meant he (supervisor) was the most senior person on site during the night- shift and was tasked to resolve issue the managers within the value streams were unable to resolve. This required him to assume responsibility for multiple work areas and I believe it is this that made him more aware of the differentiated structure of the shop-floor into value streams.

The third theme uniquely identified by the supervisor was “positive morale”. This was identified as a theme in relation to a photograph taken by the supervisor of a rest-area; used by the operators for tea/lunch breaks, shown in Figure 4-60 below.

Figure 4-60 – (Supervisor) Photograph Nos. Six - Operator Mess Room.

The individual managers had a single shift-wise team of operators reporting to them. In contrast the supervisor had all three shift-wise managers and their respective teams reporting to him. Issues of morale were, in my opinion, more likely to be encountered by the supervisor in at least a couple of different ways. The supervisor, as a ‘white-collar’ worker, was seen by the plant management to be in a management role and exercising management control, including a responsibility to engage, motivate as well as discipline his reports (Dike 2012). The managers on the other hand were mainly responsible for operations. A second reason could be that the supervisor had an overview of all three shift teams and so was better able to recognise differences in the performance of those teams despite the external ‘noise’ factors being much the same. I think the perspective of being able to compare the three teams’ performance highlighted to the supervisor the issues of team morale as being a differentiating factor related to performance, whereas the hierarchical perspective of the managers was such that they were less able to make this comparison.

There were also six themes identified by the managers and not clearly identified by the supervisor. These were ‘communication throughout’, ‘dusty and dirty’, ‘mix order and sequence of mixing’, ‘first aider / people’, ‘production tracking / output’ and ‘traffic movement’. These themes seemed to be more focussed on the operational level of the value stream, and connected to the practical aspects of running the production areas on a daily basis. Just as the themes mentioned by the supervisor were more existential in nature, the themes mentioned by the managers were more concrete and practical, connected to daily production issues as opposed to a longer term view.

These are only tentative findings, based on a single photo-elicitation interview with a supervisor. It was interesting to reflect on these in trying to grasp the complexity of visual communication in the shop-floor context. I was particularly interested to know if the needs from, and contribution to, visual communication were different depending on different levels of the hierarchy, based on the assumption that the visual communication is part of the overall performance management system (Bititci et al. 1997). Despite both groups (managers and supervisors) being shop-floor based, there is some limited evidence here that they had different perspectives, based on the themes that they elicited. Their respective focus seemed consistent with their hierarchical positions. This could suggest that the visual communication, if it is aimed to be coherent as a communication system, particularly in the context of a performance management system, should recognise this hierarchical contingency.

4.4 <u>Conclusion</u>

The aim of accessing and measuring the correlation between the intended and interpreted meaning of visual communication has required the use of a novel research design. This was achieved as a four step approach using participant-led-photography, photo-elicitation, ECRS, and a questionnaire. These tools enabled this research to elicit the psychological constructs of mangers that author visual communication, resulting in the identification of ten key themes from across the organisational value streams.

The use of photo-elicitation within a Repertory Grid Analysis design meant the themes were elicited in a bi-polar (dichotomous) nature. This was a significant asset in the creation of the questionnaire. It provided ‘dimensionality’ (Pike 2007) to the manager’s constructs, which meant they could be used to both categorise (construct-wise) and discriminate between (rating wise) a number of examples of visual communication selected from the shop-floor. This feature of photo-elicitation, in the context of a Repertory Grid Analysis design, enabled it to be used to create a measurement instrument. This was then used to establish an intended to interpreted correlation for visual communication.

This questionnaire was administered to twelve manager and eighteen operators at Automotive UK, with each person rating the same ten photographs of visual communication examples from the shop-floor. The administration of this questionnaire provided me with confidence of the practicality of using such a technique in organisations in the future. It was easy to administer and easy for those engaged with the research to grasp its intention.

The subsequent data analysis, using exact match contingency tables, provided an insight into the use of visual communications at Automotive UK. It provided a way to ‘visualise’ visual communication within the context it is being used, employing the natural language of those using them. The importance of contextual knowledge for sense making of the data also points to the need to establish methods that can be exercised by those within the workplace to access, in an objective way, issues such as visual communication effectiveness. This was my central aim at the outset of this research and having conducted this research using the design and methods described I am confident about its utility and benefit to practising managers.

A significant finding from the research was the way in which the themes identified by the individual managers were closely bound to their individual value streams and the imperatives driving those value streams. The context of visual communication could be seen not only to deal with the needs of a mass production environment but was viewed by the managers as directly connected to the drivers of their particular sub-environments, i.e. value streams. These drivers ranged from physical needs such as a safety focus due to large stand alone manually operated machines, to business drivers requiring a focus on profit margins.

An analysis of the findings has shown that the visual communication could be grouped into three potential groups. Where visual communication had been engineered by the organisational management to be treated as a standard, with corresponding standardised design and insistence on its use, then the related correlation rating was comparatively the highest. Characteristically these tended to have clearly defined titles and labels to indicate their use along with policies about their upkeep and review. A second group formed some of the lowest ranking in terms of effectiveness rating. These consisted of visual communication that were often defined by, and used within, individual value streams to serve local purposes. They were typically not standardised or incorporated into bureaucratic processes. The third group were a combination of the above two, consisting of often poorly defined and/or labelled visual communication, but where the individuals regularly using them somewhat agreed about their use and therefore meaning. In addition the relatively higher headline rating for these communications is a little misleading. As discussed above, this score also consisted of incorrectly identified visual communication by outside value streams that have augmented the score with exact matches, but in fact they have been misled by rouge titles or other misleading labels. This last group highlighted the issue that often the visual communication which was relatively poorly designed was reliant, maybe even by design, on the contextual knowledge of those using it for sense making. It could be that the original creator of these visual communications had defaulted to relying on the capacity of the value stream members for contextual knowledge to bridge the gap for design deficits.

In the next chapter I have discussed the findings from this research and how they contribute to our thinking about some of the key issues to emerge from the literature review, i.e. issues such as organisational imperatives, hierarchy and performance management systems. I have also discussed the research design and methods and what has been learnt of their suitability to access visual communication effectiveness.

5 Discussion

This chapter has been divided into two broad areas. In the first section I have considered the implications of the research findings in respect of the literature review. I have particularly discussed how this research has informed the perspective of organisations as systems. In the second section I have looked at the utility of the research design to access visual communication, and have considered issues that have emerged having had first-hand experience of using the research methods.

To help contextualise this discussion I have used the cybernetic systems model (Scott 1992) shown below in Figure 5-1. The results from this study and the implications to organisations can be described with reference to different parts of this diagram.

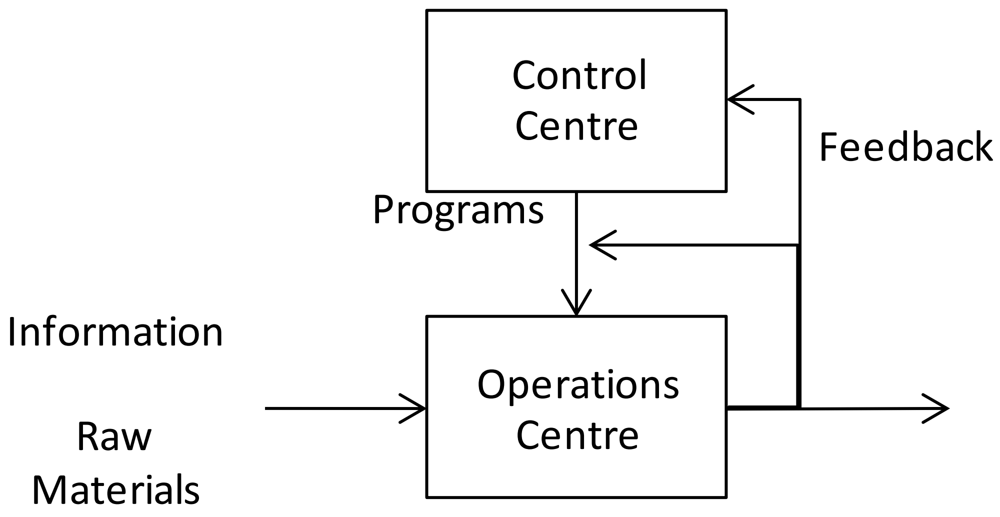


Figure 5-1 – Modified Model of Cybernetic System

(Scott 1992, p81, adapted from model by Swinth)

Organisational Imperatives - The very nature of mass production organisations is said to impose certain operational imperatives (Schmidt 2005, Thompson 2004). These imperatives are central to the trade-off decisions that have to be made by mass-production organisations to profitably run their operations (Schmidt 2005). The operations management triangle (Schmidt 2005) asserts that there are three such imperatives and there is a need to constantly seek balance between them; to balance the substitutability between inventory, demand information and available capacity. Schmidt (2005, p93) states that "...a higher level of capacity can substitute for relatively lower levels of inventory and information, a higher level of inventory can substitute for relatively lower levels of capacity and information, and a higher level of information can substitute for relatively lower levels of capacity and inventory". It is relevant to reflect in this section on the findings for an organisation that fits the definition of mass production (Thompson 2004), to see what is informing the themes elicited by those working at its ‘technical core’ (Thompson 2004), i.e. shop-floor, and to understand the role that visual communication is playing.

Control - Viewing the organisation as a cybernetic system is focussed on how objectives are cascaded and feedback is utilised to regulate the organisation. This is connected directly to issues of control (McAuley et al. 2014, Boulding 1956). Three different types of formal control arrangements have been identified (McAuley et al. 2014). These are bureaucratic, output and cultural. Bureaucratic controls relate to policies and procedures that specify how tasks should be completed and the associated appropriate behaviours. Output control is where feedback is provided to those that are being controlled such that this feedback itself elicits appropriate behaviours. Cultural control is the control of operators through identifying and aligning their values to those which are considered appropriate by the organisation. I will discuss how visual communication is affecting control, and also the foundations that act as enablers to allow visual communication to be effective.

5.1 Organisational Imperatives.

The cybernetic systems model shown below (Figure 5-2) is helpful to identify the context of visual communication, and how the blend of imperatives that managers meet within their respective value streams influences their motivations for using visual communication.

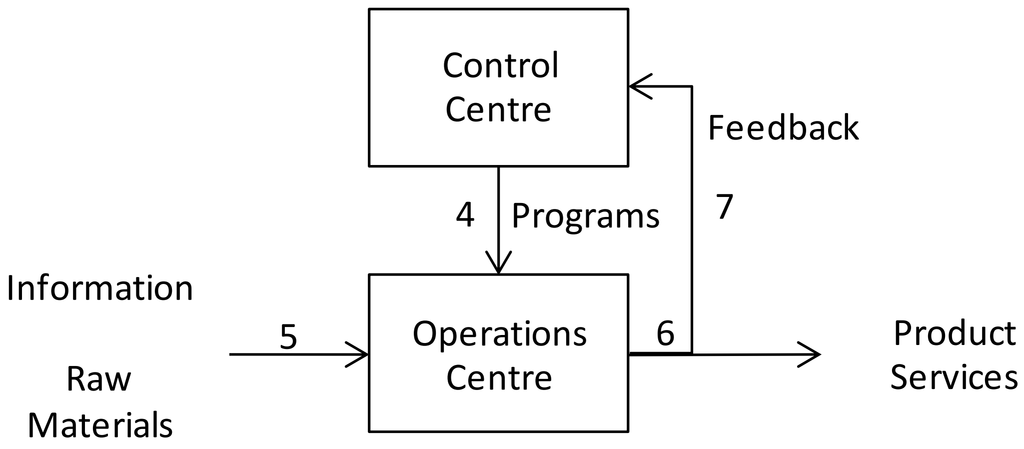


Figure 5-2- Modified Model of Cybernetic System

(Scott 1992, p81, adapted from model by Swinth)

The information flows shown by the arrows numbered four, five, six and seven above, highlight critical communication that enable the organisation to function. In this research there were examples of visual communication that were selected by the managers that represented these different information flows;

- **Machine Isolation Procedure** - shown earlier in photograph number one (Figure 4-37). This shows an example of a procedure related to the health and safety policies. This particular document described the procedure for safely disconnecting a large hydraulic press machine from energy sources, and was used to ensure safety for the operator when the machine was being cleaned or repaired. This can be said to be connected to safety protocols, and in the above diagram (Figure 5-2) this is referred to as 'programs' that emerge from the 'control centre'.

  In the case of this hydraulic press isolation procedure, the actions required by the operator can be well defined, and there are typically few exceptions to the norm. In such a case, where no variations in the 'transformation' process are desired, the use of Tayloristic operating procedures are considered efficient and effective, and ensure that the operators are clear about the actions they are to take (Simons 2013).

  The standardisation of processes, by controlling the inputs, is a relatively (management) resource hungry way for affecting control, compared for example to simply monitoring the outputs (Simon 2013). This is because in addition to stipulating the procedures, which are a visible artefact of this system, the organisation also selects and gives training to those conducting these activities. This complements the procedure, ensuring that the input components to the transformation process (labour, capital, information, energy, materials….) are utilised such that they result in the correct output components (Simons 2013).

- **Production Planning Board** – shown earlier in photograph number four (Figure 4-34). This board was used in one of the value streams to schedule the production process. Production planning is related to ensuring that production processes can "...provide the finished products in appropriate quantities, at the desired times…" (Hax & Golovin 1977, p1). In relation to Figure 5-2 above, this is an example of information flows shown by arrow number five.

  The production planning decision making systems can be broadly grouped into three categories (Hax & Golovin 1977). The first are the longer term strategic decisions that involve capital investments and the design and layout of facilities. The second, related to medium term tactical decisions, are connected with aggregate demand planning. Finally, there are the short term operational decisions which involve the detailed day by day production scheduling (Hax & Golovin 1977). The first two levels, strategic and tactical, can be thought of as being connected to the policy or control centre (Figure 5-2). They determine the very size and shape of the operations centre. The visual communication referred to in the planning board example is connected with the third level, operations level, and it is more appropriate to think of this as being an input to the operations centre (Kingsman 2000). This is because in addition to the physical raw materials and components that feed into the operations centre, there is also a corresponding need for information input, to instruct the production team about what and when to produce.

- **Communication Board** – shown earlier in photograph number two (Figure 4-27). This board, which is updated daily, visualises information about the performance of the production process. It is reviewed each shift by the operators, and each day by the managers. It is used to regulate the behaviour of those on the shop-floor towards the intended goals. This board is an example of the information flows represented by arrows six and seven in the above diagram (Figure 5-2). These communication boards are considered to be at the heart of the performance management process (Bititci et al. 1997) at Automotive UK. The objective of this process is to provide diagnostic feedback to the respective levels of the hierarchy so that measurement against the goals can be made. This enables timely actions to be taken to correct and actively manage the performance of the organisation towards achieving its stated goals. It can be thought of as a "proactive closed loop control system" (Bititci et al. 1997, p3).

Having identified that the examples of visual communication selected by the managers in the case study represent a variety of different types of information flows in respect of the cybernetic perspective of organisations, it is also important to point out some further complexities. Note that in the above diagram (Figure 5-2) the operations centre is shown as a single entity. However, the shop-floor at Automotive UK was physically organised as six different production areas, based on the concept of cellular manufacturing (Liker 2003). The intended purpose of organising the shop-floor in this way was that it allows each area (value stream) to focus on producing a limited range of products (Rother et al. 2003). Products that must be produced in similar ways are grouped together and are produced in value streams where the entire process required to produce them has been co-located (Abdulmalek & Rajgopal 2007). This enables the equipment to be right-sized (Jones et al. 1997) and the layout to be configured to establish efficient movement of products from machine to machine. It can be argued that to represent Automotive UK correctly in the above cybernetic system diagram (Figure 5-2) the operations centre should be sub-divided to show it as six differentiated recursive elements. Recursiveness is the idea from systems theory that describes the repetitive nature of systems, i.e. within Automotive UK, which is itself seen as a system, there are further systems within it. These sub-organisations are distinguished as systems, and are discrete within the overall organisation (Luhmann 2002).

This physical differentiation at the level of the shop-floor also has to be considered alongside the social organisation, to help further understand the usage of visual communication. As well as the physical segregation into six discrete areas, the structure of the social organisation was also split into differentiated groups. This enabled a cross functional group of operators, managers and functional specialists, such as maintenance technicians and process engineers, to own and run their particular mini-organisation (value stream). This type of organisational design has been characterised as a 'value stream' or 'product centred line/staff organisational' structure (Liker 2003, Woodward 1965). It is consistent with the ideas of "autonomous" or "self-managing" work groups (Cummings 1978) that are espoused within socio-technical system theory. These are groups that are responsible for relatively whole tasks, with discretion over work methods, task schedules and assignment of workers to different tasks (Cummings 1978). One important aspect of this group design is that the "...feedback necessary to control variances from goal achievement [is] within the unit rather than external to it. This self-regulating capacity is hypothesised to lead to greater productivity and worker satisfaction" (Cummings 1978, p625. Word in square brackets added by the author).

At Automotive UK, in this physically and socially differentiated environment, it becomes possible to understand why there were differences in the elicited themes from the managers. It is clear from the emergent themes, and the subsequent exact match data, that there was not a uniform emphasis on each of the imperatives in each of the value streams.

Of the six separate production lines, it is useful to compare value streams number two, three, and four. This is because these three value streams were almost identical in respect of layout and machine tools. However, of these three, one had the production machines connected using automatic conveyors, resulting in a continuous flow production line. This value stream produced a handful of different part numbers for just two customers. A second area was a high variety small batch production area producing around 200 different part numbers. This area did not have any automated conveyors, instead relying on the operator to load and unload each machine. Finally the third area was somewhere between the first two, producing around two dozen part numbers, using a mixture of manual process with some additional robotics and automation. All three value streams each had the same basic machine layout, but with differences in the levels of automation that were being used to connect them. Thompson (2004, p) stated that "...technology is an important variable in understanding the actions of complex organisations". At first glance all three of these value streams could be characterised as mass production "long-linked technology" (Thompson 2004). However, there were clear gradations in how this technology had been applied to correspond to the needs of the specific customers and it is relevant to discuss how this impacts the use of visual communication.

In Figure 5-3 below I have aligned the three different value streams mentioned above with their respective levels of automation. I have also added the themes elicited by each of the managers from that area. The themes from these managers reflect that their focus on the imperatives for their respective value streams are not all the same, despite what seems at first glance to be the application of the same technology.

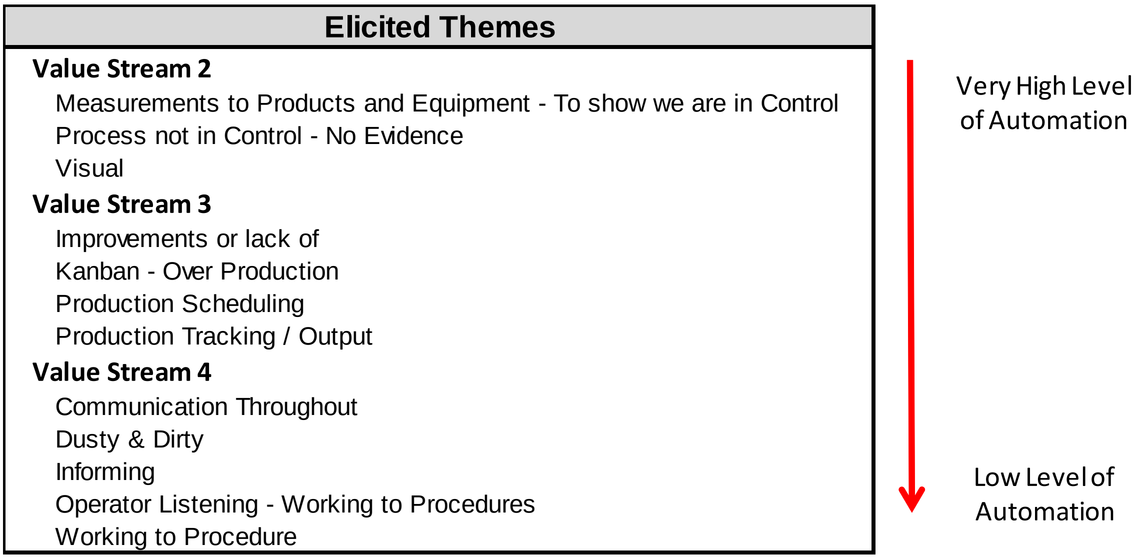


Figure 5-3 – Value Stream & Levels of Automation

In the area with the highest level of automation (value stream number two), the manager has highlighted process and product related issues as key focal points. This is understandable because in this area there were relatively few operators, and they acted more as technicians to a heavily automated process. In addition the customers for this production area, who were tier one suppliers to car manufacturers, were obliged to impose stringent requirements in terms of quality and data recording protocols for traceability. This clearly emerged from the elicitation process and can be seen in the themes identified by the manager from that area.

This can be contrasted with value stream number four which was an area where there were relatively low levels of automation. This value stream had a correspondingly higher density of operators relative to the first two areas. Here the elicitation process revealed themes that corresponded to the demands of the customers and the technology choices that had been made to satisfy those demands. It was an area where there were a greater proportion of manual processes requiring much more intervention from the operators due to the need for frequent product changes. This was necessitated by materials availability, machine reliability, skills availability, and changing requirements triggered by customers.

The point here is that a simple analysis of the technology, characterised as mass production, or only looking at the layout, may be insufficient when considering the role that visual communication has to play. To an observer, the layout of all six areas could look very similar, but the term "technology" in its broader sense is useful to elaborate. Perrow (1967) describes technology as the "work done in organisations…that is, organisations are seen primarily as systems for getting work done, for applying techniques to the problem of altering raw materials - whether the materials be people, symbols or things" (Perrow 1967, p195). If an effective end-to-end, intended to interpreted, visual communication system is to be created to support, for example, a performance management system, it is necessary to recognise the vertical differentiation of the shop-floor itself into discrete value streams and not to treat it as a single organisational department. This is effectively to recognise that the shop-floor is not a single socio-cultural entity (Seppanen & Valiverronen 2003), but has been designed into discrete value streams, which correspondingly affect discrete socio-cultural sub-environments, and set the context for the needs of visual communication.

Currently from the reviewed literature it would appear that this shop-floor level vertical differentiation into value streams is not embraced by performance management literature. This is despite recognising several decade ago that product centred line/staff organisations exist (Woodward 1965), and that bureaucratic hierarchical structures are a good way to manage in organisations (Jaques 1990).

Perrow (1967) alludes to the issues created by shop-floor differentiation in stating that he views technology as an independent variable, and that the "...arrangement amongst people for getting this work done as a dependant variable" (Perrow 1967, p195). Arguably this supports the view that visual communication, as an arrangement amongst people for communication, is contingent on technological choices. The shop-floor has been differentiated in terms of different manufacturing technology, to create different value streams. Furthermore, it has been socially differentiated into teams of individuals focussed on discrete areas and customers. This informs us that the use of visual communication cannot be uniform in each area. It is likely that different value streams, as different socio-cultural environments, may need to use visual communication to focus on issues specifically important to them.

So far I have discussed how the use of visual communication, as part of the cybernetic system, should recognise the generic and unique imperatives of the environment and sub-environments within which it is being used. In the context of cybernetic systems it is relatively easy to stipulate the input, process and output imperatives. However, just as the shop-floor is differentiated into value stream areas focussed on specific customers, the visual communication must also be aligned. It is by understanding the value stream imperatives and uniquely blending the use of visual communication that could then contribute to a coherent communication system. Visual communication usage has to acknowledge these contingencies, in recognition that these differentiated structures are themselves designed to cope with the particular needs of the shop-floor, which in turn have to respond to customer requirements in a profitable way.

5.2 Visual Communication - Control

In this section I have discussed the issues of using visual communication for the purpose of management control (McAuley et al. 2014), and some of the foundational elements that are pre-requisites for it to be affective.

It has been argued that in mass production organisations there is a need to engineer the environment to achieve a relatively routine, analysable, and predictable task environment (Perrow 1967). This is to ensure that the 'technical core' of the organisation (Thompson 2004) can be operated without the dynamics and perturbations (Luhmann 2002) of the external environment disturbing its smooth running.

Figure 5-4 below shows the ten prioritised themes from across the organisation; a summary of the psychological constructs of the mangers in relation to the shop-floor visual communication at Automotive UK.

Value Stream	Theme	Unique Construct
2	Communication Throughout	1
	Dusty & Dirty	2
3	Mix Order and Sequence of Mixing	3
	First Aiders / People	4
4	Workstations and Quality	5
	Operations Cards - Quality Set-ups	6
5	Process not in Control - No Evidence	7
	Measurements to Products and Equipment - To show we are in Control	8
6	Improvements or lack of	9
	Production Tracking / Output	10

Figure 5-4 – Key Themes Motivating Visual Communication at Automotive UK

What is seen in this list is that the motivation of the managers for (visual) communication is driven by needs of stability and standardisation. The themes are associated with a variety of visual artefacts related to 'systems' that exist in the organisation to affect stability. Examples of these are;

- **'Communication Throughout'** - An example of visual communication related to this particular theme is the Communication board (photograph number two - see appendix M2). This board was used to standardise several aspects associated with communication. This was in connection with the frequency of communication, the topics that were spoken about, and the format of the information that was presented to operators and managers each day. It was aimed to communicate, orientate, prioritise and co-ordinate the activities of the various elements of the hierarchy to manage their respective objectives.

- **'Mix Order and Sequence of Mixing'** – A good example of this is the Mix Scheduling board (appendix M4). This was also standardised in terms of the frequency for updating it, and who was required to attend the meeting held for this updating process. Once populated it defined the production schedule and sequence for one of the production areas. It ensured that only what was necessary was manufactured, and that if there were shortages of materials already known about then those could be verbally communicated and alternative products agreed upon.

Several photographs used for either the photo-elicitation or with the questionnaire show visual boards that were used to structure and standardised the communication. The managers, as architects of these different elements of communication, have created systems of structured communication in the context of a rationally organised effectively closed system (Scott 1992). This is consistent with the expectations of a mass production environment.

The focus of the visual communication can be seen to be directly related to operational control issues. The focus is on men, machines, and materials. The purpose is to ensure that planned output is maintained whilst keeping the operators safe and productive. In this respect they are consistent with the cybernetic model presented above (Figure 5-2). The visual communication themes point to controls related to the process, its inputs and outputs.

The photo-elicitation highlighted the managers' motivation for using visual communication as comprising mainly bureaucratic and output (diagnostic) forms of control. The diagnostic forms were related to monitoring the outputs and taking action based on their analysis. An example of this can be seen in theme ten (Figure 5-4), which refers to tracking the production output.

The form of control that was not immediately obvious in this research was that of cultural control. The themes and comments collected from the managers during the photo-elicitation did not fulfil the definition of cultural control or social coordination, i.e. "a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration..." (Schein 2010, p18). However, it is interesting to discuss the three types of control, i.e. bureaucratic, output and cultural, as they are not mutually exclusive

(Kunda 2006) but arguably interdependent (Ouchi 1979). I will argue below that despite mainly identifying examples of bureaucratic control, as well as some output controls within this research, in fact cultural control is present but it is subsumed within the category of bureaucratic control, once its context is considered. This is important because it highlights the complex social context within the organisation that underpins the legitimacy of visual communication. Ignoring this socio-cultural context (Seppanen & Valiverronen 2003) would be to ignore the foundations on which visual communication is given credibility and from which it sources its capacity to affect control.

Ouchi (1979) characterises the social and informational pre-requisites for the different types of controls to be affective. He argues that output control is built on the social requirement termed 'norm of reciprocity' (Ouchi 1979, p838). This is a social norm that regulates the rules of supply and demand and the way members are expected to behave. In the context of this research this norm is partially captured in the notion "an honest day's work for an honest day's pay" (Ouchi 1979, p838), i.e. employees perceive that they are being rewarded fairly for their contribution. From the perspective of the operators, in circumstances where there is a perceived lack of equitability in respect of this 'norm of reciprocity', i.e. they feel that they are not being sufficiently rewarded for their effort, then the interpreted meaning of visual communication may still be understood relatively well, however, the perceived legitimacy of visual communication in these circumstances may be undermined. In such circumstances the ability of visual communication to actually affect control could be subverted.

What is interesting in this perspective by Ouchi (1979) is that output control is said to be foundational to bureaucratic control becoming possible. It is far from an either/or option. The mechanisms of output control create the necessary conditions for bureaucratic forms to exist. It seems rational that there has to be a level of perceived equitability between pay and value between employee and employer before an employee would give up some autonomy and allow themselves to be subjugated to bureaucratic controls, for example in the form of visual communication.

The form of output control, as seen in the context of organisations, is itself less clear cut than a simple reflection of price versus value. The internal functioning of the organisation is not a ‘frictionless market’ (Ouchi 1979, p835). There is not a daily accounting by the employee or the organisation in terms of the value added versus pay. The same bureaucratic processes that are energised to affect stability, suited for mass production technologies, are also utilised to affect stability over the 'norm of reciprocity'. These 'norms' are bureaucratically encoded to give the necessary stability for the organisation to function on a day to day basis. An example of this is that at Automotive UK there was an annual wage /salary review process. This was organised on the basis of 'collective bargaining' (Armstrong & Taylor 2014) agreements. These were mechanisms that were attempting to stabilise, in a bureaucratic way, the underlying market mechanisms that govern the employee / organisation relationship. They provided a foundation that was a necessary enabler for visual communication to affect control in the first place.

The third control type, referred to as cultural control, or as Ouchi (1979) refers to it as "Clan Mechanism" (Ouchi 1979, p836), is at first sight apparently absent in the themes elicited by the managers. It was also not immediately obvious in the photographs captured by the managers during the participant-led-photography, which seemed to focus much more on the formal processes and procedures. It could even be seen to be an unnecessary form of control in an environment which has predictable inputs and repeatable processes (Perrow 1967) such as Automotive UK. However, there are less visible aspects that underpin the acceptance of the visual communication as a form of control. This is the cultural acceptance (the willingness) by organisational members to have policies and procedures imposed on them that they individually and collectively accept. For the organisation to affect co-ordination, and to enable an orientation of the organisational members towards its intended aims, there is a need for the legitimacy of authority to be recognised. In a bureaucratic hierarchy this would be the notion of accepting orders from above as "rationally designed by hierarchical superiors” (McAuley et al. 2014, p159).

Several aspects of the way in which visual communication is being used carry this implicit understanding. An example of this is that in Automotive UK the managers are the ones that are authorised to author and place visual communication on to the shop-floor. It is forbidden for the operators to do this. A further important aspect of the visual communication from a social context is its physical location. The visual communication is displayed in locations, also referred to as 'Channel' (Shannon & Weaver 1949), which are selected by the managers. These locations are selected specifically for their capacity to create awareness, ensuring that it is actually seen. In addition there is the framing (Jappy 2013) of visual communication with the company's logo and/or management signatures. This creates an impression that this is an officially sanctioned document by organisational superiors.

It can be seen that for visual communication to work as a bureaucratic form of control it in fact requires "...social agreement on a broad range of values and beliefs" (Ouchi 1979, p838). Another way of highlighting the way in which culture is working to support visual communication is that the bureaucratic control is a type of cultural control. Arguably 'modernism' is a label that replaces traditional experience based decision making culture with an instrumental (formal) rationality, i.e. bureaucratic culture (Watson 2006). Kunda (2006) suggests that culture is just one form of control, but it could actually be that it is a prerequisite for bureaucratic and market types of control to function; culture may be underpinning their very existence. In this sense it is foundational. There has to be a cultural acceptance that the 'norm of reciprocity' will be regulated through bureaucratic processes, and that organisational superiors "...have the legitimate right to command and to audit or monitor lower persons, within some range…" (Ouchi 1979, p838). It is only when these taken for granted norms are accepted, that visual communication in the context described above can function. If these foundational understandings and expectations are not agreed upon then the visual communication loses its capacity to operate as control.

An additional issue that I would like to mention here is about stable versus dynamic stability of the organisation (Luhmann 2002), as it is relevant to me as a lean practitioner; challenging plants for continuous improvement. From a cybernetic perspective, the purpose of the visual communication (in the context of the organisational design) is to affect regulation in respect of the organisational imperatives discussed earlier and overall to affect system equilibrium (Scott 1992). However, there must be willingness for the visual communication to be adaptive as the need arises. The role of visual communication in this respect is complex. One aim is for it to communicate the organisational imperatives and to enable regulation to be affected. On the other hand it has to be amenable to adaptation to support and/or affect change. The risk with creating stability and regulation using visual communication is that whilst it can be used to regulate and maintain a balanced organisation, overly robust visual controls that do not account for the contingent need for change in the system in respect of environmental dynamics could themselves become a longer term risk. In addition to the environmental contingency, there are also the socio-psychological needs of the operators that must be considered, consistent with a socio-technical perspective. It is important for this role of visual communication to be recognised within the overall scheme of organisational communication and management. Otherwise there is a risk that the visual communication becomes a barrier instead of supporting or enabling change.

Luhmann (2002) goes further in suggesting that it could be useful, even necessary, to wittingly create an 'irritation' to the organisation (Luhmann 2002), to force it to find a new equilibrium point. This would be to ensure that controls in the organisation do not overly constrain it from necessary adaptation that is contingent with the needs of the environment. The role of visual communication as part of the control system could mean it also plays a role in initiating this irritation, as well as providing subsequent regulation based on a new equilibrium. This only further highlights the important role of visual communication in the overall scheme of communication and importantly control within the organisation.

In conclusion, in this section I have discussed the important context of visual communication in the management of the shop-floor. In this research, by engaging the managers at Automotive UK and understanding the issues that they were focussed on, this research has revealed some interesting and generalisable findings. The first of these are the generic topics (themes) that were motivating the need for the communication, and I have described these as the organisational imperatives. The second was to look at how control was being affected, in the context of these themes, through the use of visual communication. These can be summarised as follows:

Organisational Imperatives - A mass production shop-floor can be functionally and/or process-wise differentiated (Liker 2003, Woodward 1965). At Automotive UK the shop floor was differentiated into value streams, and each one had compositionally the same imperatives (Schmidt 2005, Thompson 2004). However, the overall blending of those imperatives was contingent on other factors, for example the technology being utilised. Even the context of how this technology was being applied has to be further understood to ensure the visual communication is affecting the imperatives in the right way. This further shapes the expectation of what types of visual communication are being used and the motivation behind why they are being used.

Control - Considering that the use of visual communication is part of the cybernetic system (McAuley et al. 2014, Scott 1992), effectively means that it is being used to regulate the organisation. The motivation for the managers to use visual communication can be seen in the themes that emerged in the photo-elicitation data collection. These themes (see Figure 5-4 above) are connected to the input, process and output imperatives related to the 'technical core' (Thompson 2004), i.e. the shop-floor.

The types of controls being deployed were predicted to be contingent on the transformation process and task outputs (McAuley et al. 2014). In this research it was clear that visual communication was being used to affect control and the types found were consistent with those predicted, i.e. bureaucratic and output. I have also discussed however that labelling the visual controls as simply bureaucratic or output is to over simplify them. They are arguably only able to function because of the socio-cultural context (Seppanen & Valiverronen 2003) that they operate within. This context provides important foundations for these controls, which are necessary for them to be accepted by those that are being controlled. An example of this is the ‘norm of reciprocity’ (Ouchi 1979) and acceptance of authority from the hierarchy. Any conditions that diminish these foundations would arguably also undermine the capacity of visual communication to affect control.

By identifying the role that visual communication plays in the organisation, and its importance for regulation, highlights the importance of enabling access to the intended and interpreted meaning of visual communication. In the remaining part of this discussion I have looked at the methodology used in the research. This is equally important as the findings. It has identified an original way to access the intended and interpreted meaning of visual communication in the case study site and can be used in future as a management technology to gain access to the intended and interpreted meaning of visual communication within its situated context.

5.3 Repertory Grid Analysis

The second part of this discussion chapter is a focus on the implications of the research design and methods on the findings. The research was formulated to capture data about the motivation for the messages that were being communicated from managers to operators. These themes were subsequently used to create a questionnaire. This questionnaire, as a measurement instrument, was used to compare the perceived meaning of a range of visual communication taken from within the environment common to those managers and operators. In this section I have considered the design and data collection methods and their impact on the research and findings.

5.3.1 Single Case Study – Embedded Design

In this research I used the Repertory Grid Analysis approach to structure my data collection, within a single case research design (Yin 2009). What guided me towards a single case study was Thompson's (2004) characterisation of mass production environments. He argued that these types of organisations operate their shop-floors as relatively closed systems. As such the expectation was that the messages being communicated, using visual means, would be limited to relatively few key imperatives, i.e. demand information, capacity and materials (Schmidt 2005). Informed by this expectation I elected to conduct a single site study. I felt there would be a strong correlation between what was being communicated and what was being received and decoded within this single site study. Additionally I was aware that I was using a novel design for accessing the visual communication effectiveness and felt it prudent to test and develop this at a single site before coping with the complexity of multi-site research.

The issue here is that the characteristics of this particular case study organisation were important. They provided a relatively closed environment within which the visual communication effectiveness was being measured. This stability has contributed to the success in using these methods by offering an environment which has had the opportunity to settle the meaning of visual communication. I have not tested these research methods by conducting research using the same design in alternatively characterised environments, i.e. mediating or intensive (Thompson 2004), but this issue will be discussed in the limitations section in the next chapter .

5.3.2 Repertory Grid Analysis Design

Within the case study design I used the Repertory Grid Analysis design to structure the data collection methods. The way in which Repertory Grid Analysis is used to structure research is said to be limited only by the imagination (Fransella & Bannister 1977). However, despite this there remain always three core features; elements, constructs and evaluation (Bauman 2015, Winter 2013). I have used these features to structure the next part of this discussion. This is to help explore the issues that the use of this design has had on accessing the intended versus interpreted meaning of visual communication within the organisational setting.

Elements - The first of the methods that I used was participant-led-photography (Wang & Burris 1997). The aim of using this technique was to encourage a dialogue between the managers and researcher about photographs that the managers had themselves captured from their own work environment. The photographs became objects which the managers could use to help them identify important themes relating to their respective working areas. In this way it was possible to access what they held to be important about particular examples of visual communication. This importance was related to both what they took photographs of, and what they subsequently spoke about in the context of those photographs (Wang & Burris 1997).

Empowering those from within the organisation to capture their own images is based on an assumption that visual communication in situated within a social context (Rogoff 1990). Those managers that were asked to take the photographs would have some pre-understanding (context) of the usage of particular visual communication. As such the managers were likely to capture images based on this pre-conditioning, especially because they were taking images from within their own value streams; an environment that was familiar to them. This lack of pre-understanding by any researcher would necessarily change what an outsider to that group might choose to capture. I mention this point because one of the options within Repertory Grid Analysis, for the purposes of photo-elicitation, is for the researcher to provide their own photographs (Fransella & Bannister 1977).

Taking photographs of the shop-floor, or any part of the organisation, can be considered a political act (Wang & Burris 1997). A supposed weakness of participant-led-photography is that when participants engage in such acts then it can result in de-facto self-censorship (Wang & Burris 1997). The result of any such censorship would be that themes operating at the shop-floor do not emerge, or at least do not emerge clearly. This self-censorship could be unwitting, but here the point being made is about where contentious issues are avoided. This could be as a result of where the manager recognises that the research is being sponsored by the hierarchical management, so there is a possibility of repercussions. It could also come from the fact that the managers are recording photographs from their own areas of the shop-floor, and they are aware of the potential that others from within the organisation may be able to connect the photographs with the respective managers who have captured those particular images.

My view is that conducting research within organisations (such as Automotive UK) inevitably requires seeking permission from those within the hierarchy. The request for cooperation has to be presented to the senior managers and there has to be some clarity about who you are seeking to include in the study and what you need from them. In some cases the expectation would also be to explain the benefit that the organisation will achieve from cooperation. This is a legitimate concern considering that organisational resources are being utilised.

Those that are then asked to participate in the research are not ignorant of the fact that permission has been granted by their senior managers. This may have led to some self-awareness by participants that resulted in potential self censorship and bias in the results.

Constructs (Photo-elicitation) – Photo-elicitation was used to verbalise the constructs that managers were using to make sense of their environment. The elicited constructs and resulting themes in some respects were never really about the photographs. They were being used as a projective technique (Bagnoli 2009) to enable the participants to interpret and articulate their experience of the world (Bell 2012, p4, referring to work by Oswick & Montgomery). The messages that were being transmitted to the operators by their managers, and their correspondence with reality, is to some extents a moot point. This research was primarily seeking to understand the effectiveness of communication between the managers and operators, and less about the link between the themes elicited and if they refer to an objective reality (Johnson & Duberley 2000) for either party. This point also helps to explain an important difference between the roots of personal construct psychology, of which Repertory Grid Analysis is a part, which has a subjectivist epistemology (Kelly 1963) and the positivist epistemology of this research.

The next step of the research was to take these elicited (bi-polar) constructs and to consolidate them to key themes that were operating in the organisation, using the eliminate, combine, rearrange, simplify (ECRS) method.

Constructs (ECRS) - There are some issue with the identification of bi-polar constructs using the photo-elicitation technique that I have attempted to address in this research. One problem is that the poles can be 'bent' (Neimeyer et al. 2005), i.e. this is used to describe where a realistic antonym, i.e. a word meaning the opposite, has not been identified. Another issue is that poles for a given construct can be too much or too little differentiated from each other (Hagans et al. 2000). A third is that poles that might not really belong together could be compounded, i.e. they are not really bi-poles of the same construct (Neimeyer et al. 2005).

There were two aspects to the way in which I applied the methods that were aimed to deal with this issue and to arrive at bi-polar constructs that were suited for subsequent use in the questionnaire. The first was the particular approach used for elicitation, called the "contrast" method (Neimeyer et al. 2005). This is said to be a compromise that minimizes some of the documented disadvantages mentioned above (Neimeyer et al. 2005). The second aspect to deal with the above issues was the use of the ECRS method. The particular use of this method makes a contribution to research methods as it deals with several of the weakness identified in using the photo-elicitation method, and overall improves its usefulness to create a questionnaire.

To deal with the three potential issues mentioned above (antonym, level of differentiation and compounding), each manager collapsed their bi-polar constructs from bi-poles to single themes, as the last step of the ECRS activity. This is a normalising and perhaps even sanitising of the complexity of the actual constructs, and the individually identified ‘range’ of convenience (Kelly 1963, p68) of those constructs. The ‘range’ of convenience is the distance between the two poles originally identified by the managers during the elicitation process. I consider that collapsing them from bi-poles to single poles (themes) is a valid and effective way of dealing with the identified weakness with the photo-elicitation methodology. My intention was to establish the level of communication effectiveness between managers and operators and I did not consider this recalibration of the range of convenience to a normalised level to be problematic to this research. The issue for this research was to use techniques that would arrive at suitably differentiated construct themes to enable a questionnaire to be created such that they captured the language of visual communication within its context. From a methodological perspective the use of the ECRS approach deals with the weaknesses of the photo-elicitation method whilst improving participant involvement and being relatively straightforward to administer.

The last component of the Repertory Grid Analysis is the ‘evaluation’ step, which I have briefly discussed next

Questionnaire / Evaluation (Data Analysis) - By administering each questionnaire individually, to both managers and operators, I had the benefit of sitting opposite the respondents and watching them fill out each answer sheet. It was clear that some of the respondents were more inclined to pick mid-points or polar extremes to speed up the process of filling in the questionnaire, so the design of the questionnaire is clearly important (Dillman 2007). It was this observation that guided me to base the correlation measure only on exact matches for a response level of one and two, i.e. very strong or strong agreement with each question/theme. I considered this would reduce this biasing influence.

Observing the collected data in the form of contingency tables clearly shows the clustering of the data around particular answers. Analytically capturing this clustering effect, rather than only exact matches, would have involved analysis of ordinal variable data. This in turn would have required much more sophisticated analysis tools to be used to analyse the contingency tables, such as linear-by-linear association (Agresti 2010). It would also have required significantly more statistical knowledge and manipulation. Although as can be seen in the contingency tables that often there was a strong clustering effect around the exact match data, I did not consider that these alternative techniques were particularly practical methods that managers could generally access in the organisational setting.

5.4 Conclusion

In this research the role of visual communication has been contextualised by viewing the organisation as a system. These systems comprise a number of sub-elements connected by materials and information flows. Visual communication is seen to be used in these different areas to drive and connect the organisation together. This highlights the important role it plays in organisational life.

The use of visual communication as part of the cybernetic system is what guides the intention of the message prior to it becoming encoded in a visual way, as well as providing the context for its subsequent interpretation by operators. The use of visual communication in this respect is a fundamental part of how the organisation navigates towards its overall aims. This means that the organisational context cannot be detached from the effectiveness of the visual communication as a whole. The design and methods used in this research were aimed to recognise and respect this socio-technical context, embracing the voice of those involved in the acts of communication. My use of the Repertory Grid Analysis design, consistent with a neo-positivistic research philosophy, was to access the correlation between intended and interpreted meanings, based on the view that visual communication takes place in this social-cultural context (Rogoff 1990).

The organisational imperatives and contingencies which impact what managers think should be controlled are found to be dependent on several factors. In this research, the way in which the production technology was deployed, and the structuring of the social organisation into value streams, has in part informed what managers perceived as drivers in their environment. This in turn has altered the balance of themes that were motivating their usage of visual communication. However, in a relatively closed mass production environment, such as Automotive UK, the overall imperatives were relatively limited and predictable (Schmidt 2005, Thompson 2004).

To access and understand these key imperatives for communication within Automotive UK, I developed a research design to explore the correlation between the intended and interpreted meaning of visual communication within a single case study. The use of the Repertory Grid Analysis design enabled the operationalisation of the Shannon & Weaver (1949) Communication model for the purpose of exploring visual communication. It enabled the comparison of the intended and interpreted meaning making of a range of visual communication examples, enabling the derivation of an interpretation measure. Conceptually underpinned using the Shannon & Weaver (1949) Communication model this design effectively split the research into two aspects; creating a questionnaire and administering that questionnaire.

In the next and final chapter I have summarised the research findings and have highlighted the contribution to professional practice. I have also identified the strengths, weaknesses as well as opportunities for further research.

6 Conclusion

The aims, objectives, findings, and contribution of this research are summarised in this concluding chapter, as are their potential importance to a wider audience.

In the first part of this chapter I have reiterated my motivation for conducting this research by restating the role that visual communication plays in organisations, and why being able to measure its effectiveness is an important contribution to management and organisational theory.

In section two I have drawn conclusions about the extent to which the research aims were fulfilled.

Next, in section three, I have summarised the contribution that this study makes to management and organisational theory. I have also reviewed the contribution that has been made to practice, particularly from a research design and methods perspective. I have drawn conclusions about the extent to which the research design has helped to achieve the methodological objective of conducting a neo-positivist case study exploration by applying a Repertory Grid Analysis research design.

The fourth section summarizes the strengths and limitations of this research and this has led, in section five, to looking at the opportunities for further (future) research.

6.1 Importance of this Research

Visual communication is used extensively in organisations. It is deployed to visualise many different aspects, at all levels of the hierarchy (Parry & Turner 2006, Liker 2003) and by doing so it is used as a powerful means of orientating organisational actors towards particular goals (Greif 1991).

Using visual means for the purpose of communication is not the same as knowing how well that communication is working. The adage of 'if it can't be measured it can't be managed' is relevant in this context. I was interested to know the level of understanding of the audience having seen a visual message. This is a question about what was intended in terms of meaning in the use of a particular communication and how this has been subsequently interpreted. This is what led me to my central question of “can the intended and perceived meaning of visual communication be effective?"

Answering this question however comprises some levels of complexity. Visual communication is embedded within a social context (Rogoff 1990). This must be accessed to understand the relative effectiveness of any given communication. If we inspect in isolation an example of visual communication, as an artefact of that communication, we cannot be sure what the intended message actually was. Trying to find answers to these related problems captures the aim and the subsequent objectives of this research.

Focussing at the level of a manufacturing shop-floor, this research has specifically explored the correlation of visual communication between managers and operators. This is arguably a critical communication within such an organisation as here we are referring to its ‘technical core’ (Thompson 2004). The capacity to measure this in a novel yet practical way enables insights to be made within the organisational setting that can inform the use of visual communication and ultimately how control can be affected.

This research has used a theoretically informed design that has enabled access to measuring the visual communication effectiveness between two groups. By using a case study design (Yin 2009), in a shop-floor setting, an evaluation has been made of the intended and interpreted meaning of visual communication.

This thesis contributes to the field of visual communication studies through a neo-positivist exploration using methods that put at centre stage those involved in the acts of visual communication; by empowering their motivations and voices (Wang & Burris 1997). By providing a methodology for assessing the correlation of intended and interpreted meaning of communication, using visual means, I have retained a strong focus throughout on practice based issues. This enables future researchers and managers to access the use of real world visual communication.

Visual communication, as with any form of communication, particularly in organisations, is motivated by some need or desire. This research has used a number of qualitative and quantitative data collection methods based on the Repertory Grid Analysis design (George Kelly) to operationalise this motivation, and in doing so the findings provide a numeric rating of communication effectiveness. However, more importantly, this provides insights into the contingencies that impact the messages that managers wish to communicate in the first place.

6.2 Research Aim

In aiming to establish the visual communication effectiveness, one of the objectives was to determine what was motivating its use. This is consistent with Shannon & Weaver's (1949) depiction of the way in which communication flows, i.e. that the visual communication we find on the shop-floor is an encoded message that at some point was in the mind of a manager. To determine the effectiveness of that message it has been necessary to find ways to access its intended meaning before it has been encoded to visual forms.

In acknowledging that this communication process takes place within a physical and social context which cannot be separated from its meaning (Jappy 2013, Kenney 2009), it was necessary to determine a research design that engaged those in the organisation who were responsible for the visual communication, i.e. managers, and understand from them what was driving (motivating) the messages that they were trying to communicate, i.e. their constructs.

To access the intended meaning behind a range of shop-floor visual communication, a research design has been used based on the Repertory Grid Analysis method (Bauman 2015, Winter 2013, Partington 2002, Fransella & Bannister 1977). This comprised a range of methods, a number of which were necessary to fulfill the first objective of this research, i.e. "to extract (elicit) psychological constructs from managers who author the visual communication utilised on the shop floor."

The first step was to use participant-led-photography (Wang & Burris 1997) with a number of managers. This ensured that currently used examples of visual communication were selected by them, and photographed in their situated context. The subsequent use of photo-elicitation enabled those same managers to consider these photographs in a structured interview, and to elicit their intended message (Fransella & Bannister 1977). The results from these separate interviews were subsequently consolidated using a form of content analysis, referred to as 'eliminate, combine, rearrange, simplify' (ECRS) (Training within Industry Service 1944).

The accessing of the managers psychological constructs in relation to visual communication, as opposed to other actors in the organisation, was relevant when its connection is understood to the way in which strategy is cascaded throughout the organisation (Fullerton et al. 2014, Leeuw & Berg 2011). The representation of the organisation as a cybernetic system (Scott 1992), and framing visual communication in the context of its use to affect control, highlights the need to access the visual communication from a manager's perspective.

Having accessed these psychological constructs using the Repertory Grid Analysis design (Partington 2002, Fransella & Bannister 1977) it was possible to identify the key themes that were motivating the use of visual communication on the shop-floor. By then using these themes to create a questionnaire it was possible to operationalise the motivation of managers in the context of visual communication.

The creation of a bi-polar questionnaire directly from the elicited themes provided dimensionality, both construct and rating wise (Pike 2007). This enabled managers and operators to quantitatively identify their interpretation of a range of visual communication taken from the shop-floor. It was the correlation of this data between these two groups that allowed the intended versus interpreted effectiveness of visual communication to be assessed. The inclusion in the survey design of different production areas (value streams) (Liker 2003) ensured that the analysis could be conducted within and between differentiated elements of the organisational shop-floor. This provided rich data for analysis.

In the practical setting of the shop-floor, with busy managers and operators, the balance of data quality and contact time with respondents was achieved by limiting the number of questions and photographs to be rated. This enabled the time requested from each respondent to be limited to less than one hour whilst enabling this research to collect sufficient data for analysis.

The accessing of psychological constructs from managers and using these elicited themes to create a questionnaire, followed by its subsequent administration, enabled the successful completion of the first two objectives of this study, and allowed the central aim of this research to be fulfilled.

6.3 Contribution to Practice

One of the contributions that this research makes is to organisational theory. Crafting visual communication for specific contexts and purposes requires that problems can be identified and potential improvements proposed. To be able to see how well it is doing its job of communicating requires the capacity to measure it. Being able to assess the correlation between intended and received visual communication meaning is a first step to focusing a scientific light on its use as an organisational technology.

A second contribution that has been made within organisational theory is specifically within socio-technical systems theory. The research design has enabled access to the communication that is taking place within individual value streams (autonomous teams). The contribution goes further in that in doing so it has revealed that each of the teams are focussed on specific imperatives, determined by the unique combination of contingencies found in their operating environment.

This research also contributes to management theory by supporting managers to measures the relative communicative effectiveness of particular visual communication within their situated context. It does this whilst retaining a strong focus throughout on practice based issues and in its utility for researchers and managers within organisations to make sense of the usefulness of real world visual communication.

Accessing visual communication through the use of the Repertory Grid Analysis design (Partington 2002) has provided a novel and structured approach. This research has put at centre stage those involved in the acts of visual communication. It is sympathetic to the structure of organisations and that visual communication is hierarchically directed to affect control. It brings to light and articulates the motivation of managers and in doing so this thesis provides a novel methodology for assessing the effectiveness of communication using visual means. The research design has enabled data to be collected about the motivation for using visual communication and its subsequent interpretation. Particularly in this case, due to the effectively closed environment of the shop-floor (Thompson 2004), the visual communication had to be studied within its context of use (Jappy 2013, Kenney 2009).

Within this overall structure the methods used for data collection were also linked together in a novel way;

The participant-led-photography (Wang & Burris 1997) used digital cameras to capture visual communication within its situated context. This method is not new but the literature review did not reveal its use in this type of research design. The participant-led-photography provided rich and diverse photographs as inputs for the subsequent steps of the research. Its use proved to be efficient, engaging, and easily followed by those asked to contribute to the process.

The second step, photo-elicitation method, was used as a projective technique (Bagnoli 2009). It empowered the respondents to speak about their experience of the work environment (Bell 2012, p4, referring to work by Oswick & Montgomery) using their natural language (Banister et al. 2011, Pike 2007). This was a novel way in which to extract the motivation of managers for using particular visual communication. These elicited constructs (Kelly 1963) provided the foundation from which it was possible to operationalise their motivation for the use of visual communication.

The use of ECRS was also novel. Various approaches have been used by others to consolidate elicited comments to key themes (Pike & Kotsi 2016, Ab Aziz et al. 2015, Michie et al. 2005) but I found no evidence to show that the ECRS process had been used previously in this context. Its use represented a form of content analysis (Symon & Cassell 2012); a four step systematic way in which the elicited bi-polar constructs were consolidated to core themes. A benefit of this method was the empowerment it gave individuals to consolidate their own elicited constructs which reduced the chance of miss-interpretation, particularly in such a context specific communication.

6.3.1 Dissemination Strategy

To disseminate the findings of this research back to the research participants as well as internal and external professionals, a number of different strategies were employed. A variety of different stakeholders were identified and a dissemination strategy was formulated for each group.

The first group were those that were directly involved and contributed to the research. This group comprised a number of managers and operators. A summary presentation was prepared and delivered to the managers comprising a one hour seminar. This provided them the opportunity to see the results of the research as well as ask questions. The operators were not provided any feedback. The issue was raised with the Human Resource department for Automotive UK and it was felt that there was no discernible benefit from providing feedback, considering that the data collection was 19 months earlier, and in addition it would have meant losing a minimum of 18 hours of labour time from the production line, for which substitute labour would be required. The presentation used as the basis of the discussion with the managers is shown in Appendix P.

The second group are those Lean trainees within the wider Automotive Corporation that could benefit from the findings. For this group it was necessary to distil the findings from the research, as these managers are expected to practically implement Lean theory in their respective sites. The format of this dissemination was a half day workshop (which is scheduled annually), conducted in China, comprising a mixture of classroom theory and exercises as well as shop-floor activity. Appendix Q shows the presentation used.

The third group is the general population of Automotive UK. The purpose of this communication was to orientate those within the organisation to some of the key findings from the research. There was not an expectation that they would be able to individually readily apply any of the findings. However their familiarity with the intended purpose of visual communication makes them more amenable to accepting the need for visual communication usage within the organisation. Appendix R shows a copy of a newsletter prepared for global transmission in

June 2017. This is a quarterly newsletter that is used to communicate the progress of lean implementation across the organisation. This newsletter is made available to all 17 sites, to staff, and direct hourly workers.

The fourth group are the executives of the company that can sponsor or affect the use of visual communication. For this group I have prepared an executive summary that provides a summary of this thesis. See Appendix S.

Finally I have included an example of where I was given the opportunity to present to a group of industry executives during a presentation evening for delegates who had completed their six sigma certification. These were managers from a number of UK based automotive, manufacturing and consultancy organisations, such as Action, Anopol, Brose, Capella, Gestamp, Jaguar Land Rover, KPIT, Maier, Multimatic, Radshape Sheet Metal, Stadco, Toyota, WHS Plastics, Valeo and ZF Lemforder. The presentation used for this is shown in Appendix T.

6.4 <u>Strengths & Limitations</u>

An important issue regarding the strengths and limitations of this research was the use of a single case versus multiple case study approach. Different rationales are proposed that can support justification for using a single case study (Yin 2009), i.e.;

- When a single case represents the opportunity to test a theory where the propositions within that theory can be tested in that context.
- When a case represents an extreme case.
- When a case represents a typical case.
- When the case study will be revelatory; making visible some "...phenomenon previously inaccessible to social science enquiry…" (Yin 2009, p48).
- When conducting a longitudinal study.

Although, in terms of the list above, this research was not intended to represent an extreme or longitudinal study, the above criteria were relevant and the selection of this type of organisation along with the specific design and methods justified a single case study approach.

The case study design could also be justified by the fact that it is impossible to separate the phenomenon's variables from the context (Yin 2009). The use of methods such as participant-led-photography and photo-elicitation were necessary to capture communication as it takes place in the real world working environment. I cannot envisage how meaningful control of the various variables that operated in this research could be replicated or controlled outside of their actual situational context (Gray 2004).

One problem highlighted earlier about using a single case study design is that it does not give an opportunity for any significant adjustment or tuning of the research approach in case of problems (Yin 2009). However I felt satisfied that the research methods were effective and unproblematic during the single case design and it would be interesting in the future to repeat them elsewhere.

The decision to adopt a single case embedded approach was also based on some practical issues. As mentioned in the introduction chapter, Automotive UK was a relatively developed Lean site, and despite having the choice of other UK sites I was interested to understand the use of visual communication is this type of mature environment. I did have the choice to conduct a study at a site based in China which I also considered to be a relatively mature Lean site. I was however advised against using techniques such as photo-elicitation in any country where I did not speak the native language. This was due to the translation process that may have resulted in additional variables to the research that could have been difficult to reconcile.

An additional reason for the selection of a single case study was based on the planned use of data collection methods such as photo-elicitation and ECRS. I knew that these would be time consuming to conduct and analyse. In hindsight the one-to-one administered questionnaires proved to be very valuable for several reasons that have been discussed earlier.

I was satisfied that conducting a single case design provided me with the necessary time to conduct these questionnaires with both the managers and operators. Considering the above issues I felt justified in adopting a single case study approach. However this single case study did not have the opportunity to test the themes for organisational size, strategy and national culture (Wang &

Wang 2016) although the contingency of technology and organisational structure both featured in the specific context of this research.

Another risk with this research design was that it restricted the outcome to analysis within the context of the questionnaire design, generally looking if there was a correlation or not. Alternatively if I had used qualitative inductive methods with managers and operators then potentially additional data may have emerged from the study. However, to demonstrate a correlation may have become correspondingly more difficult in that the outcome of the qualitative study would be relatively more difficult to compare. Also it may have shifted the reliance increasingly to more qualitative methods to determine a correlation. From a neo-positivistic perspective the researcher imposed subjectivity would have raised reservations of the objective validity of the research, particularly the ability of it to be replicated consistently.

Another possible limitation is the utility of this design and methodology for environments other than those characterised as mass production. For long-linked technology environments (Thompson 2004) with few imperatives (Schmidt 2005) the use of photo-elicitation seems particularly suited. The effectively closed environment (Thompson 2004) of the shop-floor allows the constructs to be built through their replication and they become validated as being relevant to that particular environment. Other environments, for example ‘mediating’ or ‘intensive’ (Thompson 2004), may have a greater number of 'drivers' and/or greater complexity. The net result of these differences could mean that Repertory Grid Analysis is less suited.

As a final point, at a very practical level, one of the additional benefits of the design and techniques used was the relatively low amount of contact time required with individuals from the organisation. With the correct planning, allowing for shift patterns, access for interviews, time for the respondents to capture images etc., the majority of the data collection could be completed within a five-ten day period. This research design would be practical for me in my role as an internal consultant, where I typically spend one week periods at a particular site.

6.5 Opportunities for Further Research

Having discussed the contribution that this research makes to practice, in this next section I have looked at the opportunities for further research.

Automotive UK is an organisation that I have worked with for a number of years in the role of an internal consultant applying Lean methods (Towill 2010). Due to the specific research question I was interested to answer and the specific features of the organisation, the use of a single case embedded design was justified. However, having conducted this research and established the correlation for different examples of visual communication, my intention is to make interventions to improve management practices. This provides an opportunity for a longitudinal research study (Symon & Cassell 2012) to establish how these interventions impact the organisation at different points in time (Yin 2009).

A second area for further research is the use of visual communication at different levels of the hierarchy. In this thesis the tentative findings from the pilot study show that the needs from, and contributions to, visual communication are contingent to the hierarchy. This research has focussed on what I consider a critical part of this structured communication, i.e. the visual communication used between the managers and operators to cascade goals, and to enable regulations towards them. A second interface of communication that I think is important to explore is between the value stream managers and production manager/s (see shaded area in Figure 6-1 below).

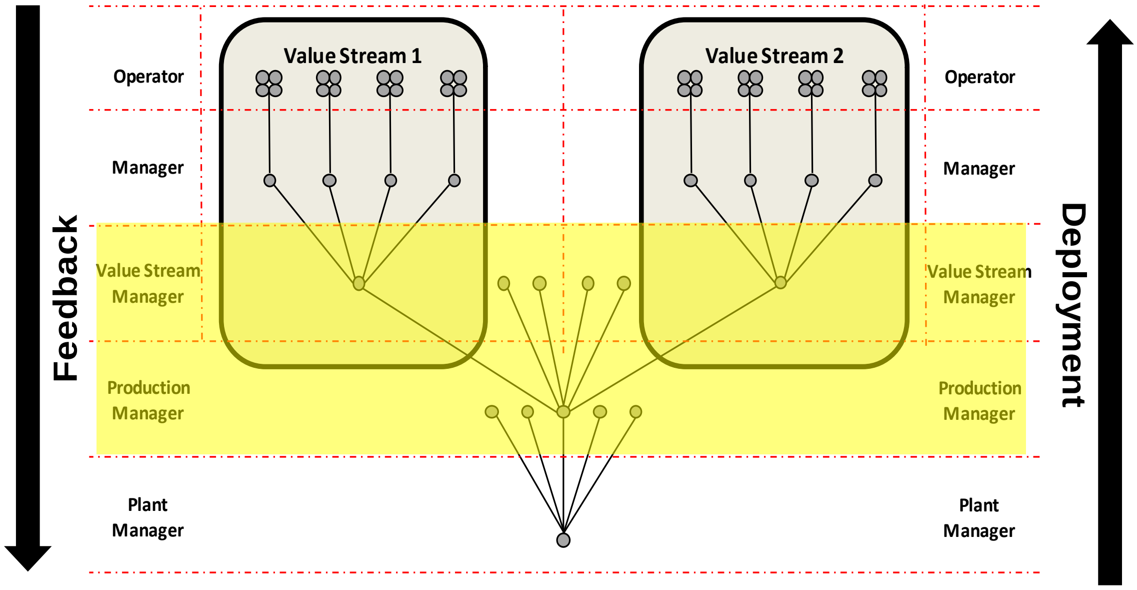


Figure 6-1 – Organisational Structure at Automotive UK

(Based on diagram by Liker 2003, p192)

My interest in this is related to the ideas of recursiveness within systems theory (Luhmann 2002). The organisation is configured based on a product centred line/staff organisational design (Woodward 1965) also known as value streams (Liker 2003). The value stream design can be repeated a number of times within a single organisation depending on the range of products. One benefit of creating physical and social differentiation in this way is to effectively form sub-organisations which enable each of these teams to identify and work towards objectives, suited to their specific value stream needs. This is because each line/staff team, headed by a value stream manager, have a common working area, product portfolio, and customers. Focussing on the interface of communication between the value stream manager/s and production manager/s (yellow shaded area shown above) would potentially reveal the imperatives that operate at this level of the organisation (rather than at the value stream level). These imperatives are particularly useful from a visual communication perspective because it is the first level in the organisation where it would be possible to capture the contingencies across all the different value streams. This could inform the use of visual communication by managers at a broader generic organisational level, and may give insights that are then applicable at a policy level, recognising that visual communication is part of the performance management system (Bititci et al. 2016).

The above mentioned studies, as potential for further research, are effectively single case studies. Having established in this research that the design provides a platform to access visual communication, it would be interesting to utilise the design in another similar type of organisation. The use of a multi-case design (Yin 2009) would further establish the utility of this design in revealing organisational imperatives and dominant types of controls (McAuley et al. 2014) in other similar organisations, and could help to reinforce the generalisability of the knowledge gained from Automotive UK.

Another area to extend the use of this research from a management practice perspective would be to conduct research in a non-English speaking country. The research would have to be led by a native speaker due to the nature of the research methods, such as photo-elicitation. The benefits however of collecting comparative data could be to provide the opportunity to assess Edward T Hall's theory relating to different cultural orientations of 'time', 'space' and 'context' in respect of communication. This research is important to inform the current management practice where defining the usage of visual communication often takes place at a corporate level, with the expectation that it will become a standardised global practice, without necessarily considering geographic (cultural) contextual contingency.

To establish the validity and broader applicability of this research design it should also be tested in those organisations that can be characterised as 'mediating' or 'intensive' (Thompson 2004). Currently the use of visual communication in organisations is over represented by studies in mass-production organisations. This is because of the three way link between visual communication, studies of this in the context of Lean theory, and due to Lean theory being dominated by literature relating to mass production organisations (Bititci et al. 2016). The use of this research design in other types of organisations would present the opportunity to validate, or extended, current thinking about the characterisation of organisational types, the key imperatives that operate there, and the forms of controls that are being used (McAuley 2014, Thompson 2004, Schmidt 2005).

In the above discussion I have proposed how the research focus could be redirected, i.e. repeating the research at different levels of the hierarchy, in similar organisations, in different contexts (non-English speaking) or in organisations that are fundamentally different in character (Thompson 2004). These are all a change in focus of the case study rather than recommendations for any significant redesign.

The final area of proposed further research is related to the conceptual model used in this study. As mentioned in the literature review, communication models can be characterised into two different types. The first types are process models (Kelly 2014, Baldwin & Roberts 2006), based on seeing communication as a message. The second types are semiotics models (Kelly 2014, Baldwin & Roberts 2006), which consider communication as the production and exchange of meaning.

The issue I have discussed below is related to the notion of communication effectiveness, as a measure of the intended message versus the final received message. There is an idea from Peircean semiotics (Charles Sanders Peirce), related to the notion of communication effectiveness, which is relevant here as I think it is arguably more representative of the relationships of visual communication transmission within social contexts.

Peirce (Jappy 2013) argues that any given visual communication document, as an artefact of some intended message, is necessarily less complex than either the message that motivates it, or the meaning of this visual communication in the mind of the person receiving it (Jappy 2013). This is in contrast to the Shannon & Weaver (1949) model where it is not explicit. In fact by their use of phrases such as encoding errors and signal to noise ratio, there is an underlying assumption that the strength of the signal can at best only ever equal the meaning of the message. The key point here is that Peirce (Jappy 2013) acknowledges the importance of social context for meaning making, which is particularly relevant in the organisational usage of visual communication, whereas the Shannon & Weaver (1949) model does not dwell on this and it is only in Weavers later paper (Weaver 1953) that this issue is acknowledged.

The issue for this research is that the creation of the conceptual model led to a research design that prioritises the meaning given to visual communication from the perspective of the managers. This is based on the assumption that they have some access to organisational imperatives that motivate the need to communicate and affect control. These assumptions in turn led to the manager's voice becoming a precursor to the creation of the themes which are the basis of the questionnaire. This voice is further privileged in the analysis when comparing only the exact match responses of the managers and the respective operators from the same value streams, based on the assumption that the managers must know the meaning of visual communication, and the operators can either agree or disagree with that opinion. The analysis, for example, does not compare the rating of the operators with each other, but only tests to see if they agree with their respective managers.

The Peircean assumption that the meaning of the sign is necessarily more complex, I believe would have led to a different research design and analysis. The very question of visual communication effectiveness, with an assumption that it can at best achieve 100%, would be challenged. It could be that the operators have a much better understanding of the meaning of visual communication as a settled meaning directly connected to organisational imperatives, due to the social context of the communication, perhaps more so even than their managers.

However, despite recognising an alternative theoretical perspective to determine visual communication effectiveness, the downside could be the possible lack of practicality in accessing this meaning in the organisational setting.

END
(56,060 Words)

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8 Appendix

8.1 Appendix A – Photograph Sequencing

The table below shows the way in which the 12 photographs taken by the managers were split into two groups. Photograph number 1 was numbered as "1", photograph number 2 was numbered "1A", etc. The odd numbered photographs without the suffix "A" were used for the photo-elicitation interview. The remaining, with "A" suffix, were pooled together to give 36 photographs. Ten of these were selected for rating using the questionnaire. These were rated by both managers and operators.

N.B. RGA = Repertory Grid Analysis

Photograph Number											
1	1A	2	2A	3	3A	4	4A	5	5A	6	6A

■ Photo used for RGA Interview

□ Photo pooled for potential use with questionnaire

Figure A1 – Photograph Sequencing

8.2 Appendix B – Prepared Questions for Photo-Elicitation Interview

Shown below are the prepared questions used during the photo-elicitation interview. These were pre-printed to ensure the consistent phrasing of the questions.

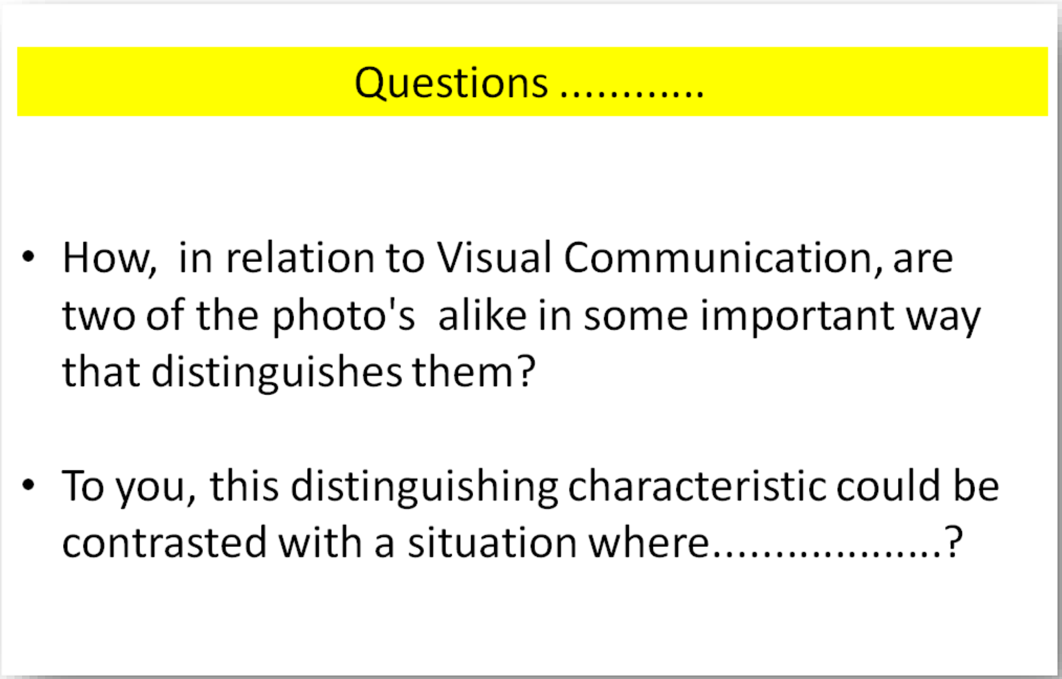

Figure B1 – Questions for Photo-Elicitation Interview

8.3 Appendix C -Pilot Study – Interview with Supervisor

Shown are the six photographs, taken by the supervisor, and used for the photo-elicitation interview. Note that some parts of the images have been masked to hide the company name and logos prior to publication as agreed with Automotive UK.

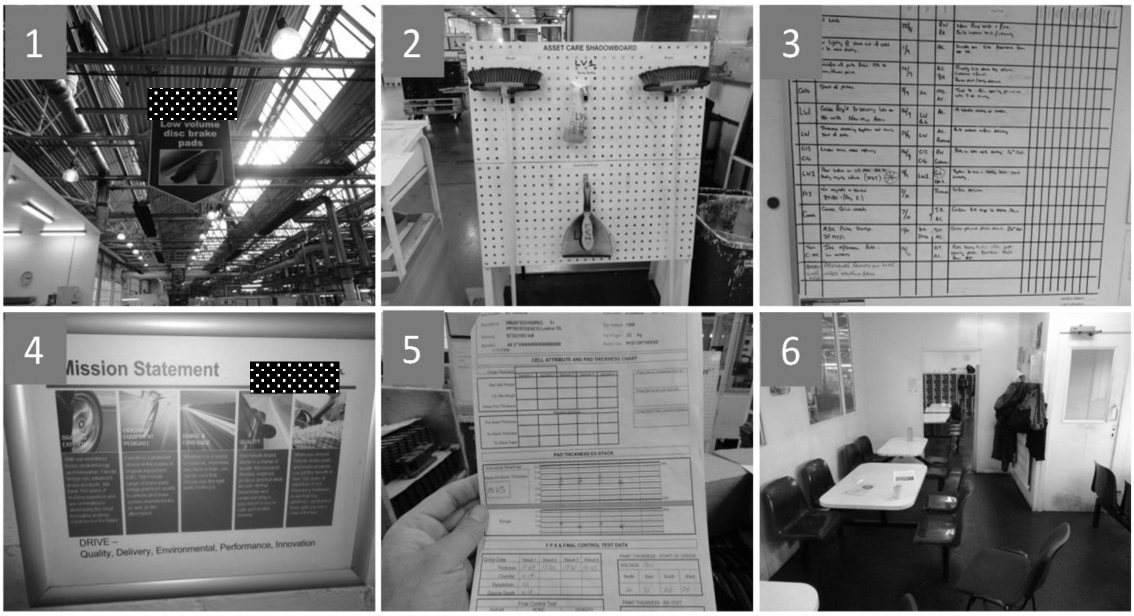

Figure C1 – Photographs - Photo-Elicitation Interview with Supervisor

8.4 Appendix D – Pilot Study – Photo-elicitation Interview Results

Shown below are the twenty pairs of elicited constructs. In each case the left hand post-it note is a record of the elicited pole, in response to question one shown in appendix B. The right hand post-it note records the emergent pole which is in response to question two, shown in appendix B.

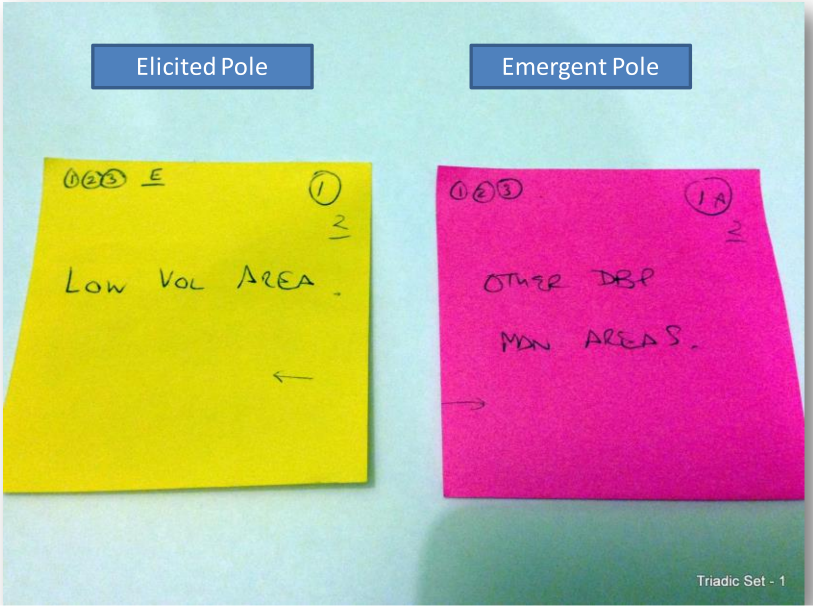

Figure D1 – Pilot Study – Photo-Elicitation Interview – Triadic Set 1

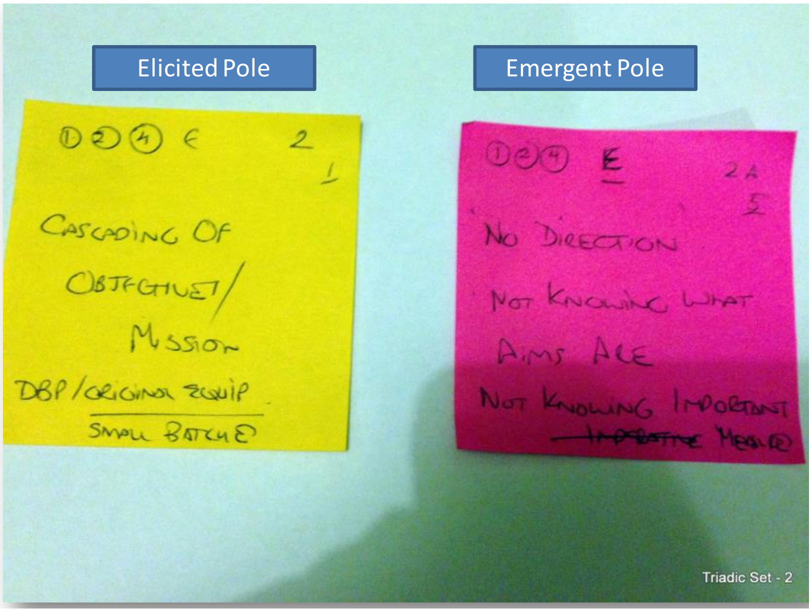

Figure D2 - Pilot Study – Photo-Elicitation Interview – Triadic Set 2

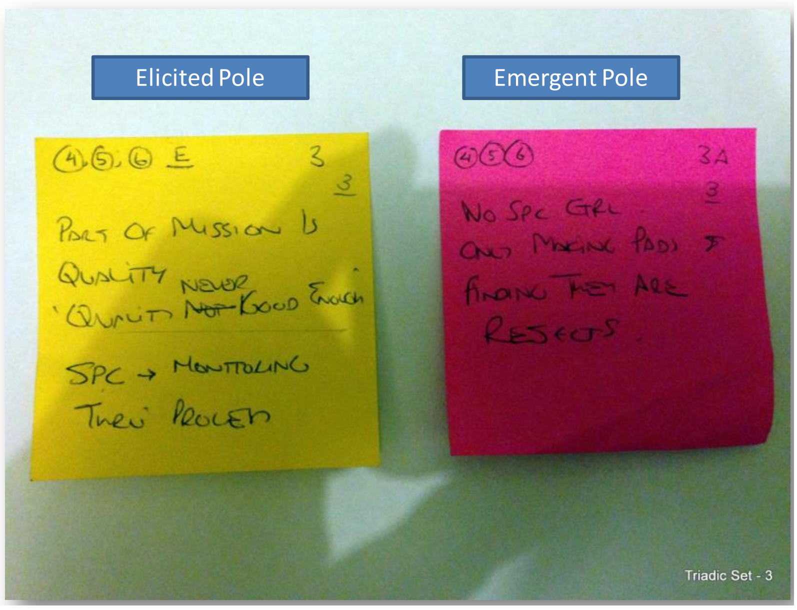

Figure D3 - Pilot Study – Photo-Elicitation Interview – Triadic Set 3

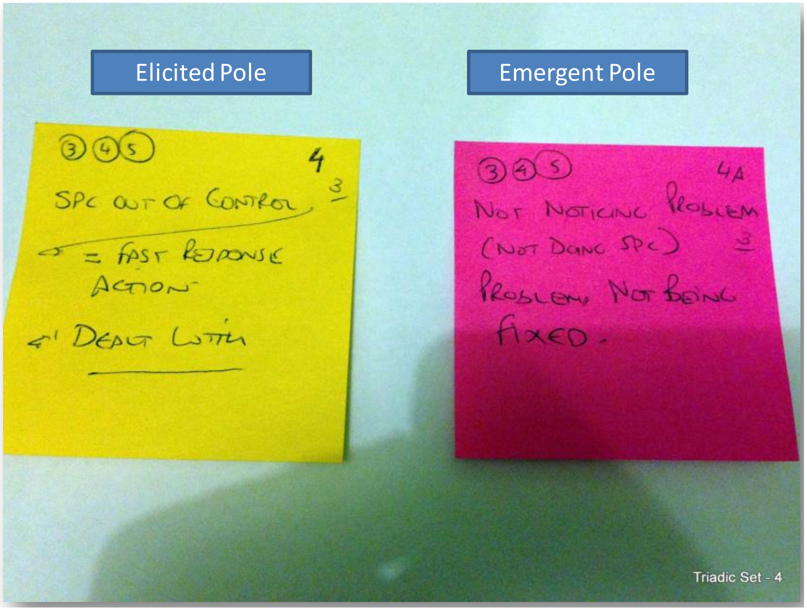

Figure D4 - Pilot Study – Photo-Elicitation Interview – Triadic Set 4

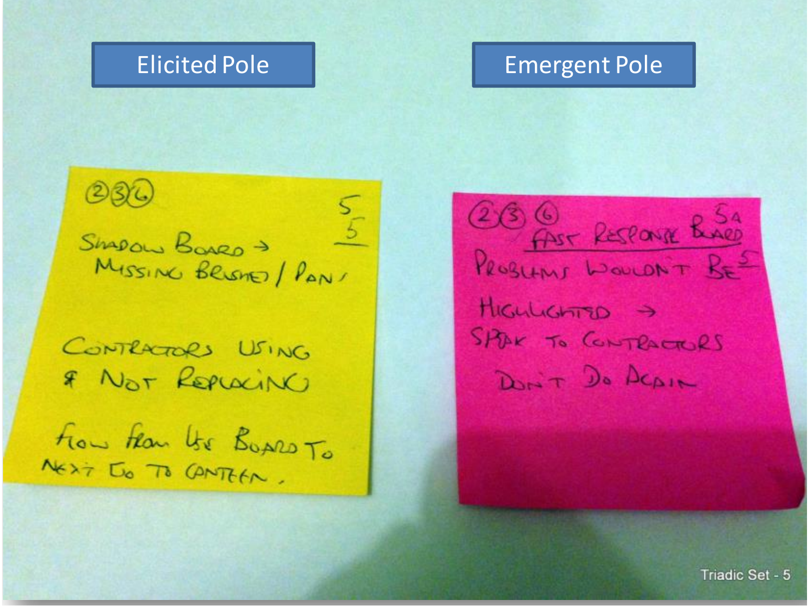

Figure D5 - Pilot Study – Photo-Elicitation Interview – Triadic Set 5

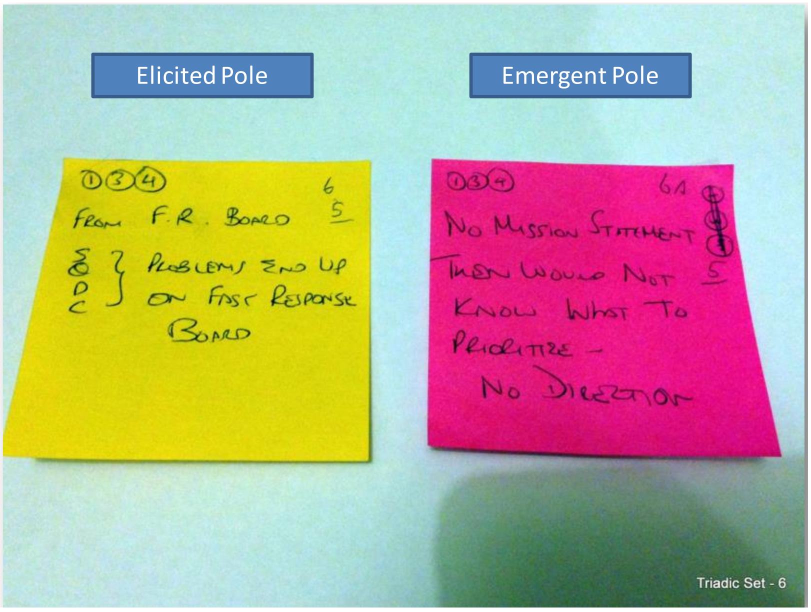

Figure D6 - Pilot Study – Photo-Elicitation Interview – Triadic Set 6

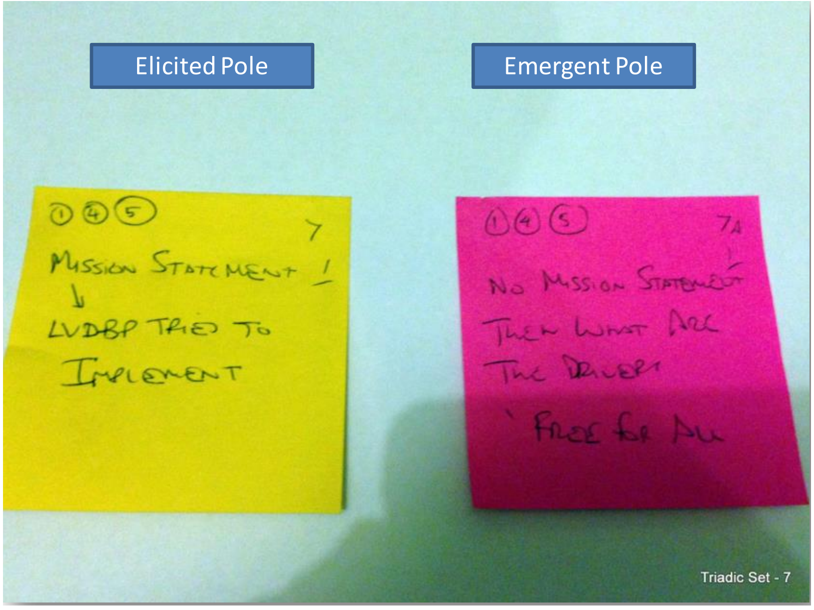

Figure D7 - Pilot Study – Photo-Elicitation Interview – Triadic Set 7

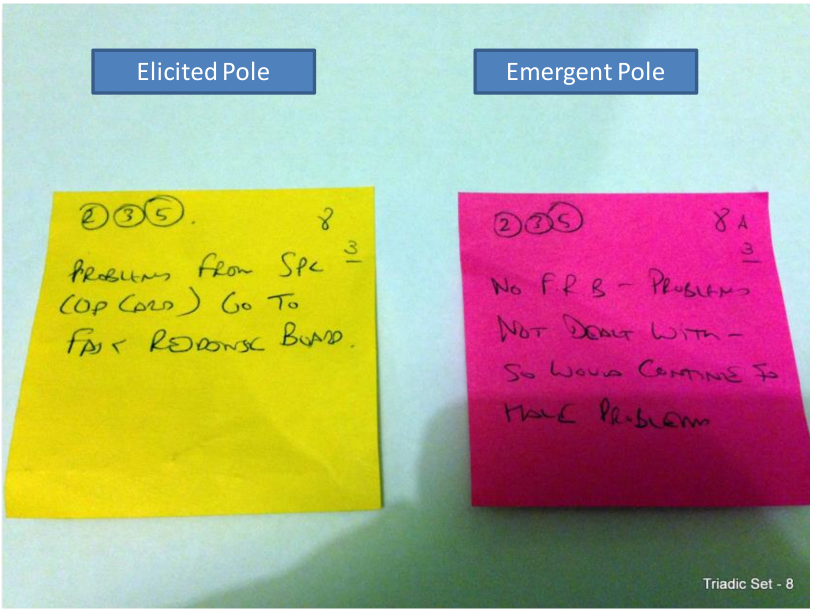

Figure D8 - Pilot Study – Photo-Elicitation Interview – Triadic Set 8

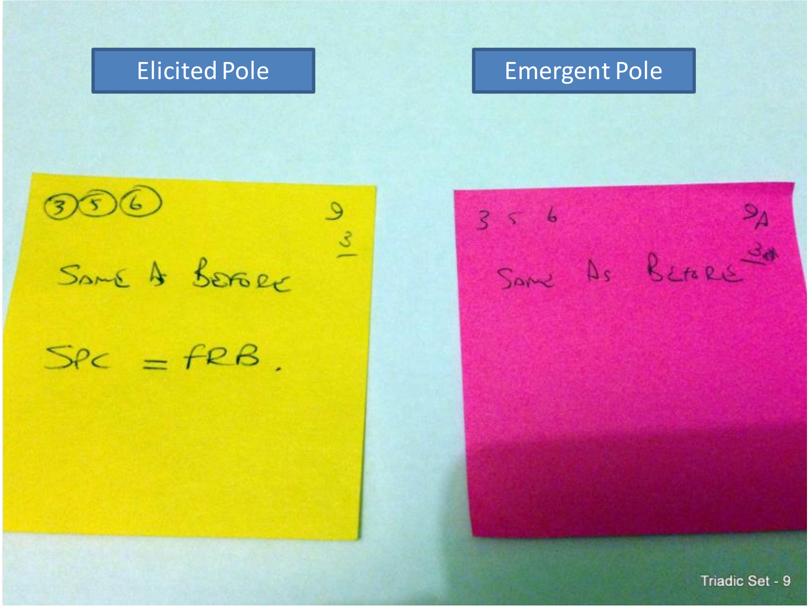

Figure D9 - Pilot Study – Photo-Elicitation Interview – Triadic Set 9

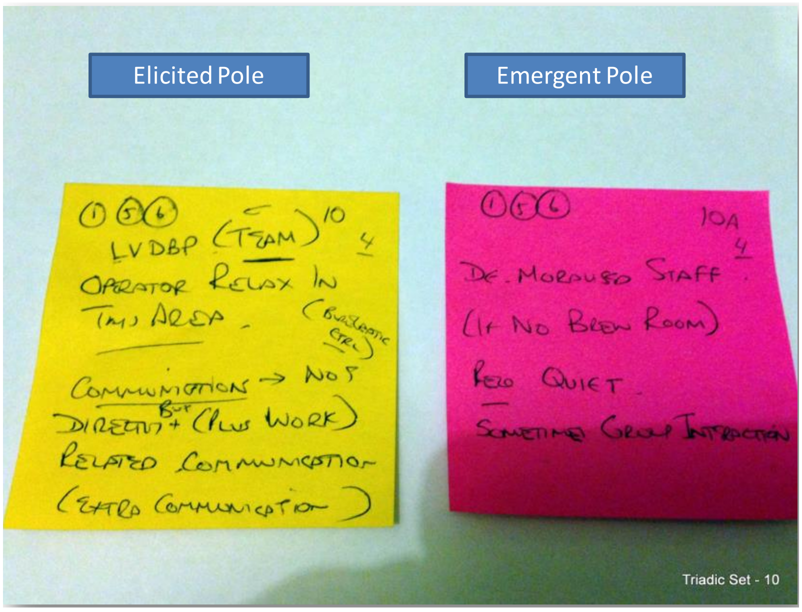

Figure D10 - Pilot Study – Photo-Elicitation Interview – Triadic Set 10

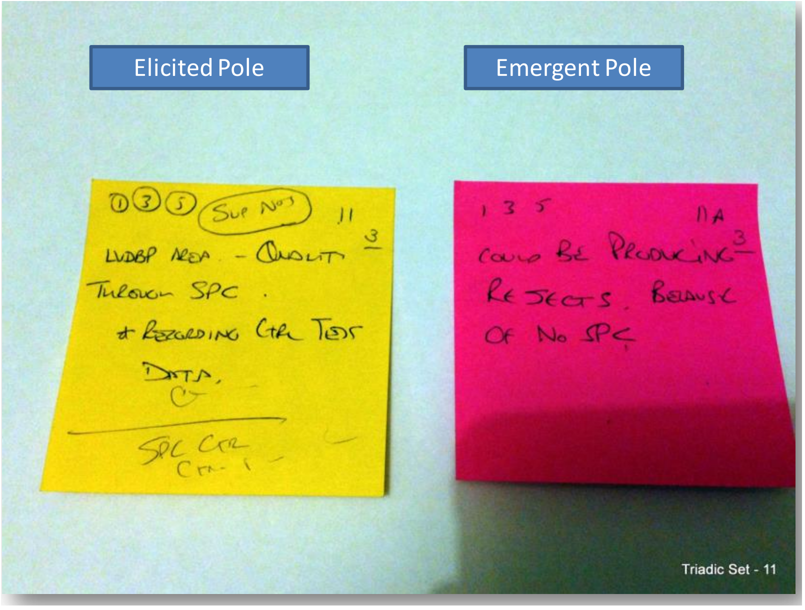

Figure D11 - Pilot Study – Photo-Elicitation Interview – Triadic Set 11

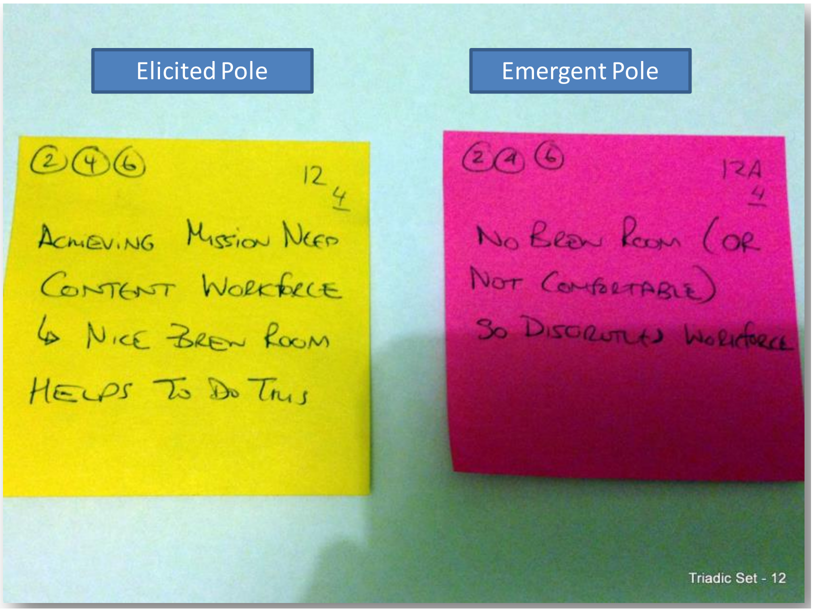

Figure D12 - Pilot Study – Photo-Elicitation Interview – Triadic Set 12

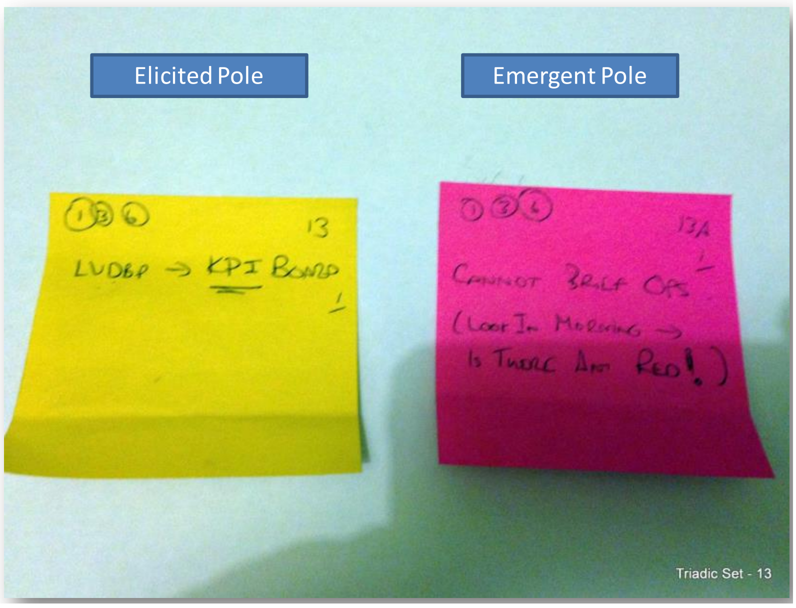

Figure D13 - Pilot Study – Photo-Elicitation Interview – Triadic Set 13

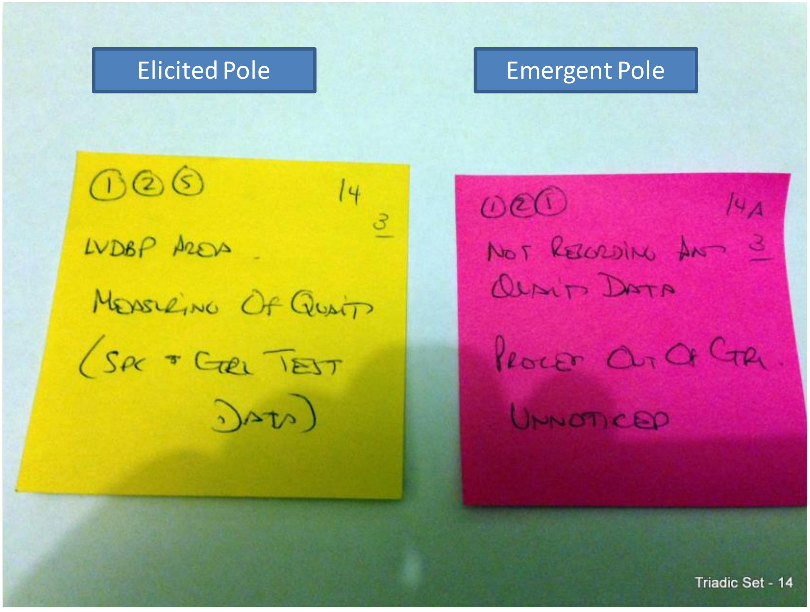

Figure D14 - Pilot Study – Photo-Elicitation Interview – Triadic Set 14

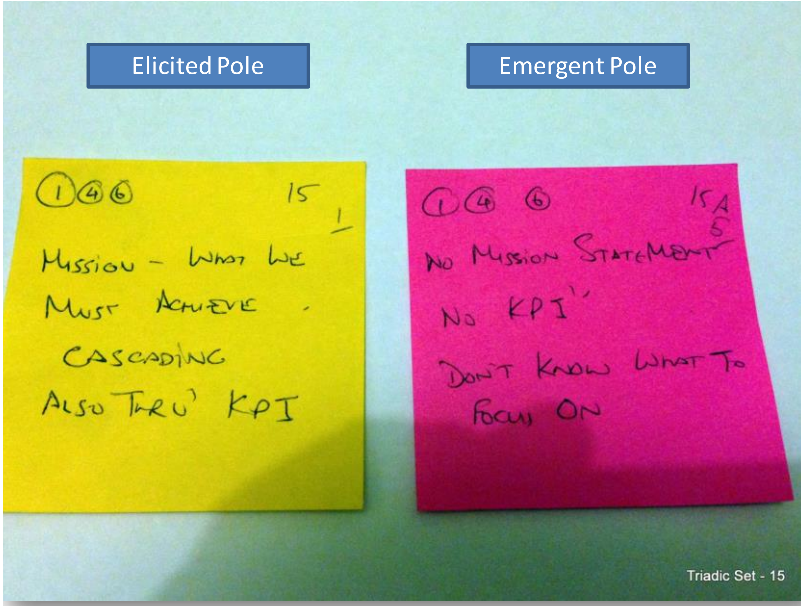

Figure D15 - Pilot Study – Photo-Elicitation Interview – Triadic Set 15

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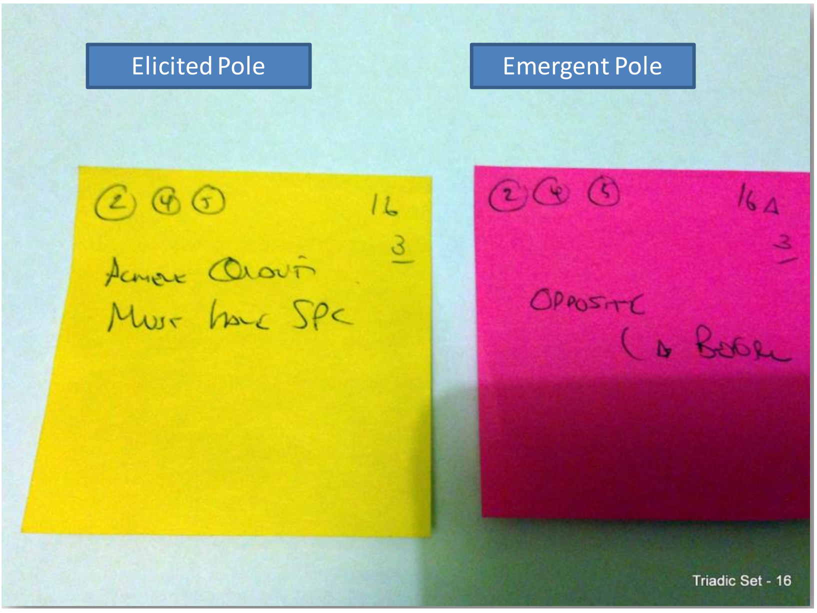


Figure D16 - Pilot Study – Photo-Elicitation Interview – Triadic Set 16

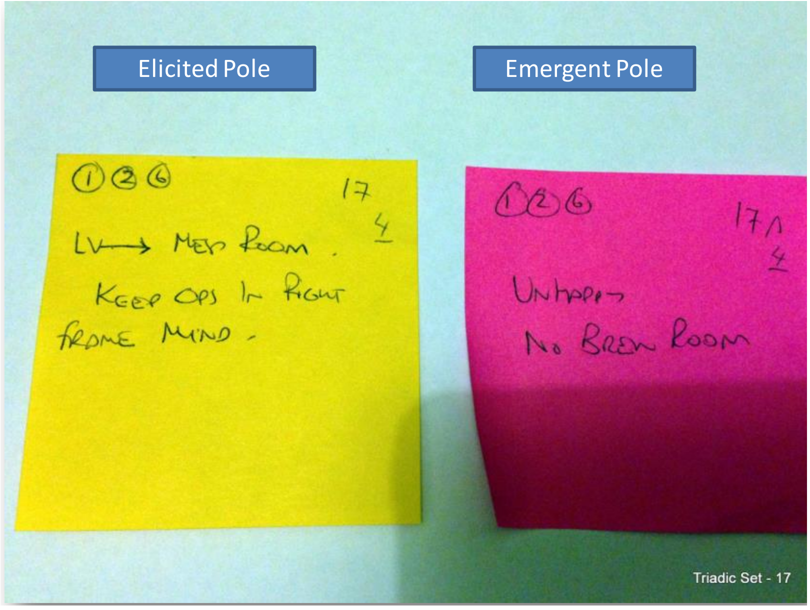


Figure D17 - Pilot Study – Photo-Elicitation Interview – Triadic Set 17

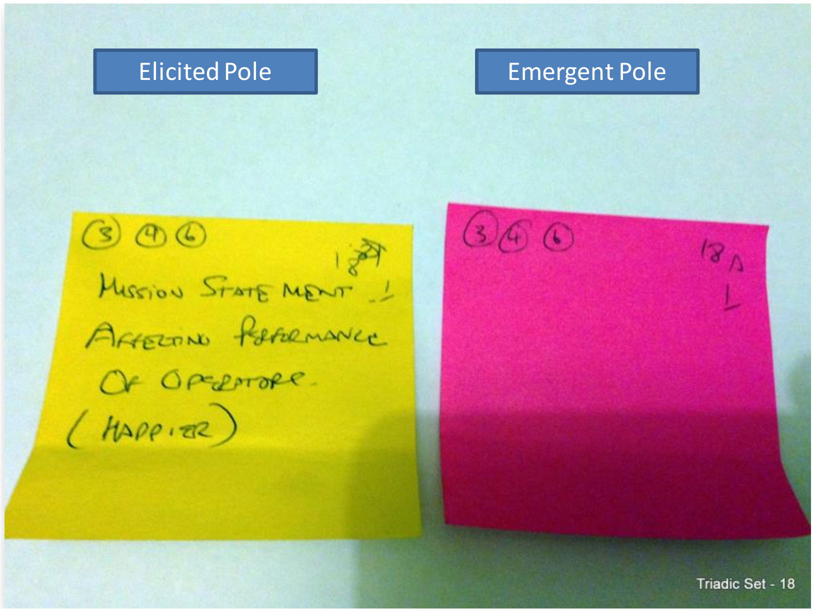


Figure D18 - Pilot Study – Photo-Elicitation Interview – Triadic Set 18

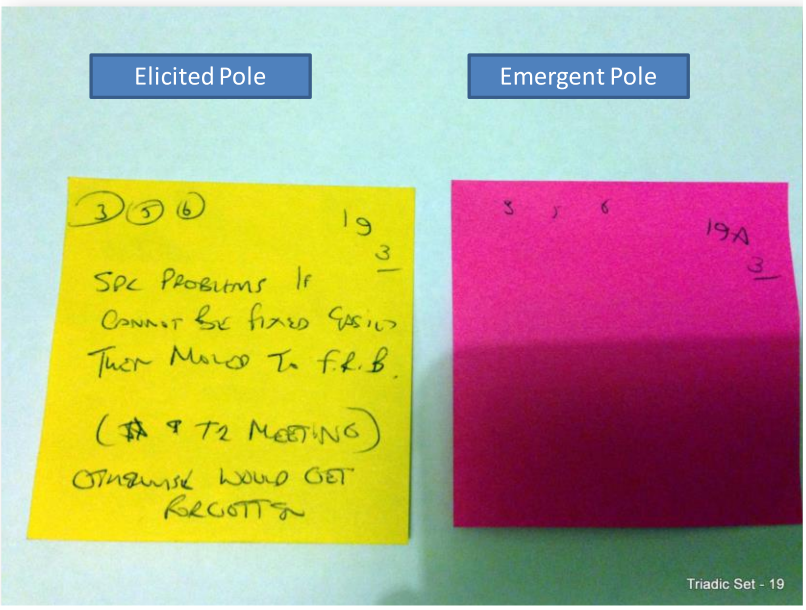


Figure D19 - Pilot Study – Photo-Elicitation Interview – Triadic Set 19

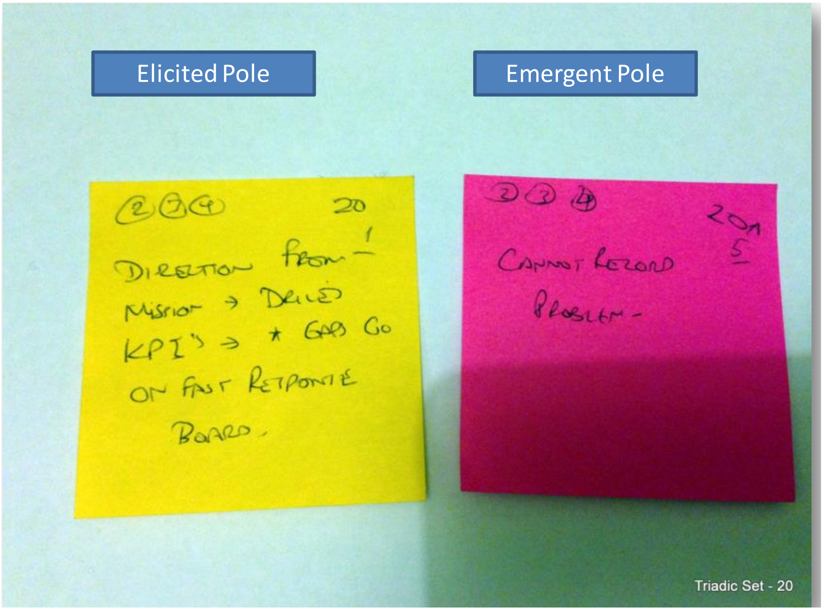


Figure D20 - Pilot Study – Photo-Elicitation Interview – Triadic Set 20

8.5 Appendix E- Consolidated Themes (from Supervisors Constructs).

The 20 bi-polar constructs shown above in Appendix D have been simplified using the ECRS methodology (eliminate, combine, rearrange, simplify). Shown below are the five themes that emerged from this consolidation. Note that this activity has retained the bi-polarity. In the case of the pilot study these were used directly as end-labels for the questionnaire. In the main research the ECRS process was slightly modified to enable the collapsing of the bi-poles to single themes. These were then re-expanded to define the end-labels and effectively control the range that each questions represented.

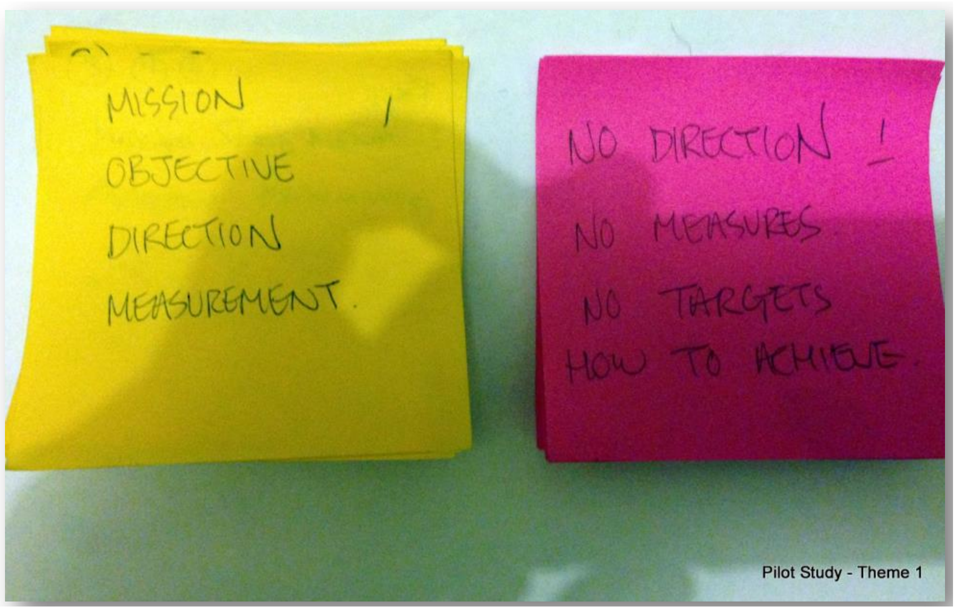


Figure E1- Consolidated Theme 1

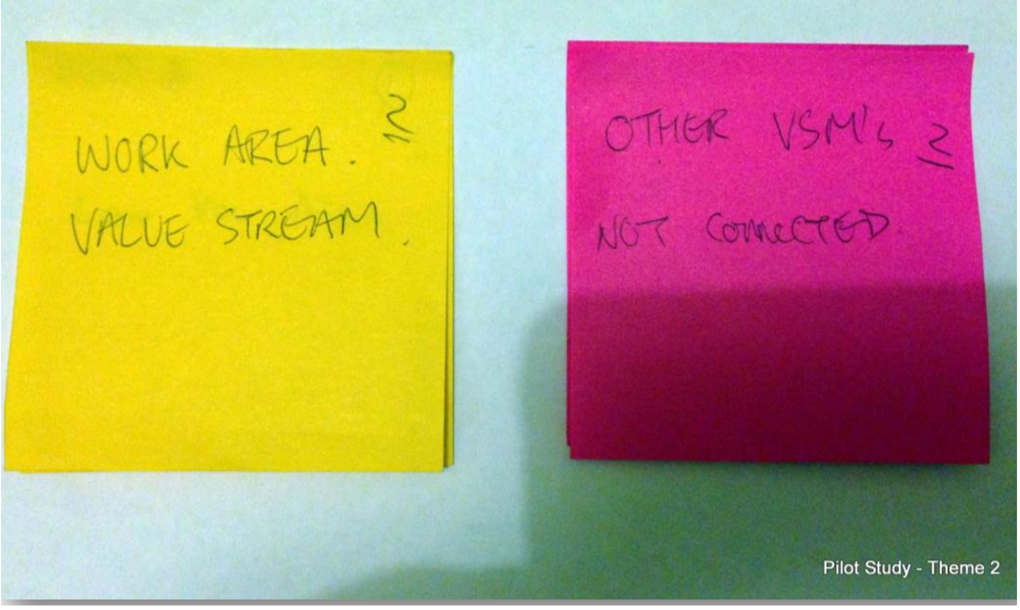


Figure E2- Consolidated Theme 2

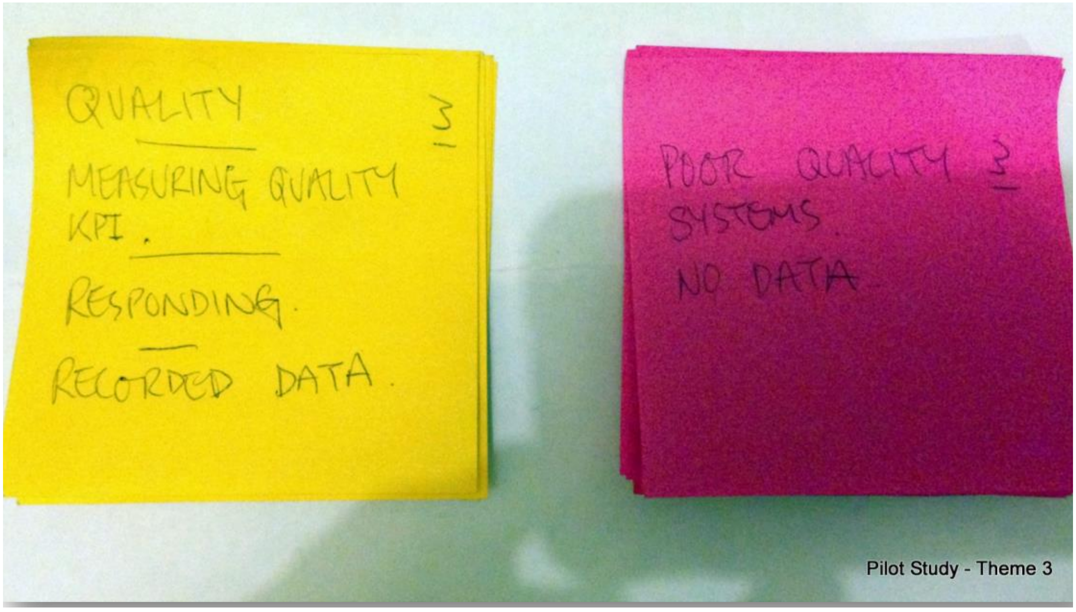


Figure E3- Consolidated Theme 3

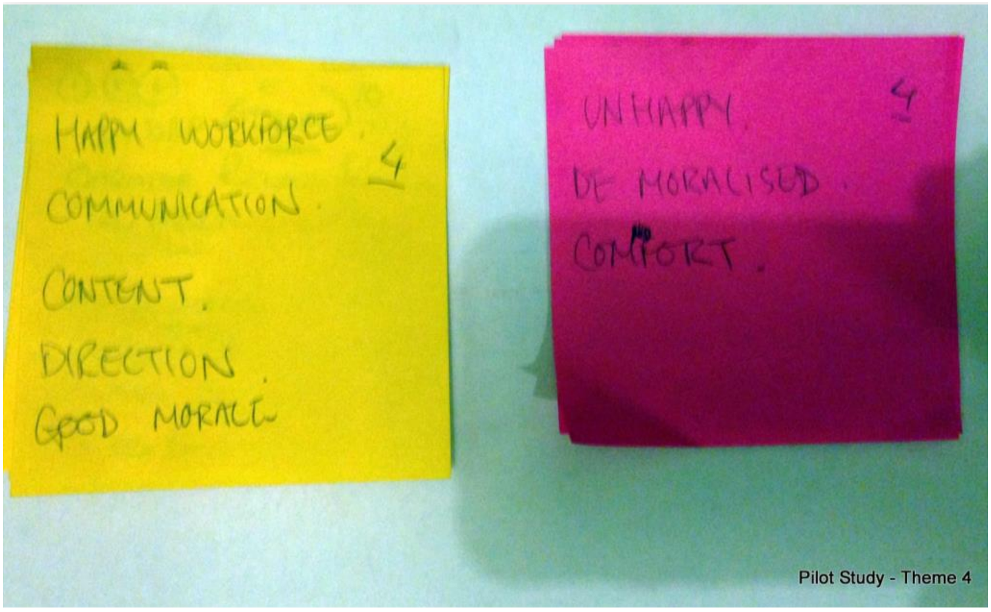


Figure E4- Consolidated Theme 4

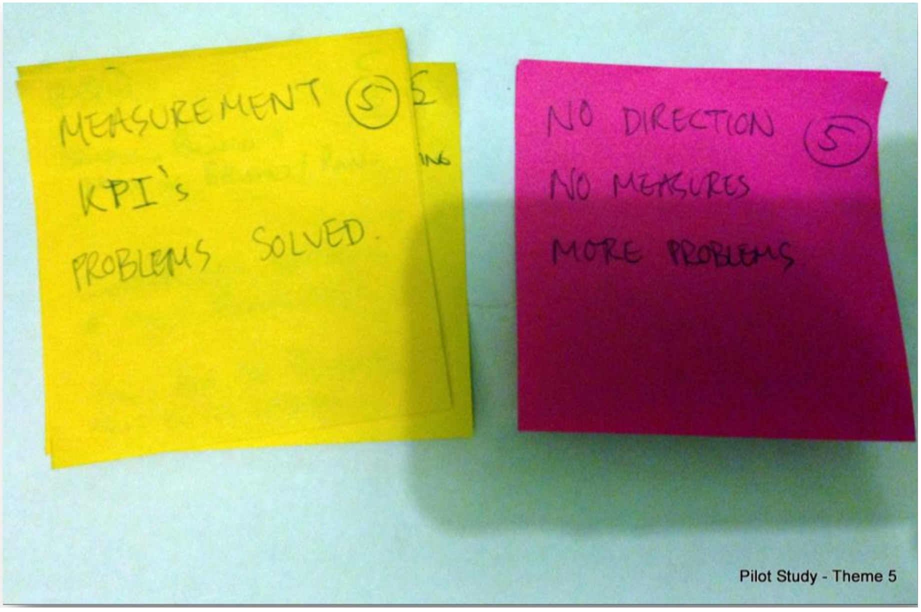


Figure E5 - Consolidated Theme 5

8.6 Appendix F – Pilot Study - 6 Photographs used with Questionnaire

Shown below are the six photographs rated by the supervisor using the questionnaire.

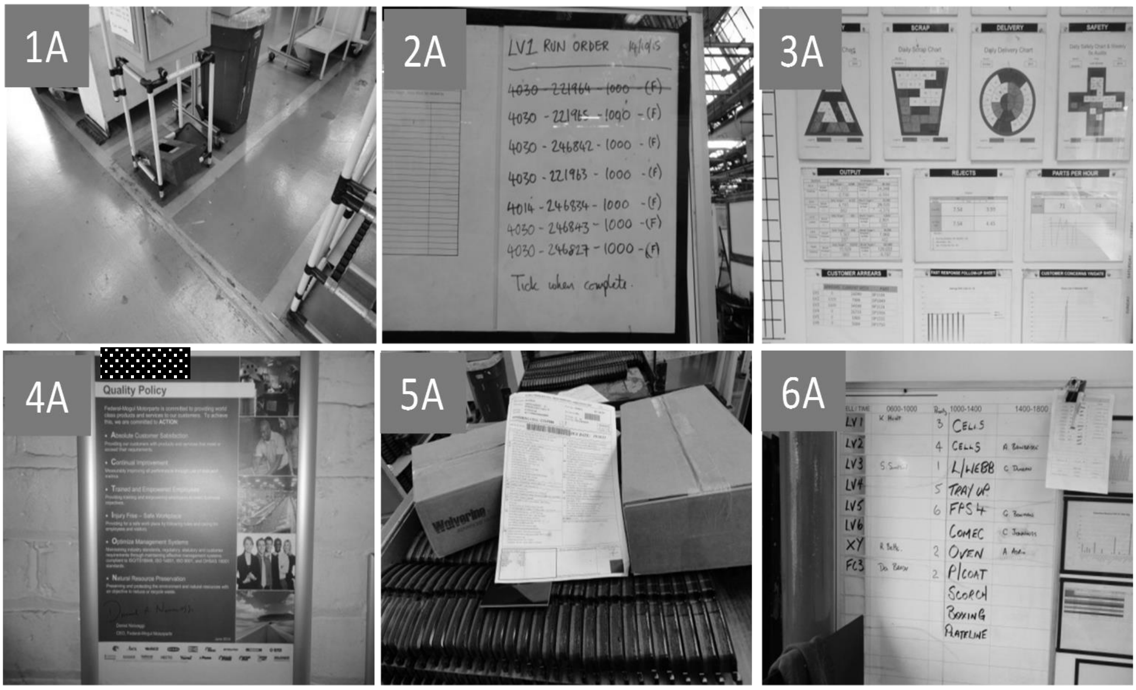


Figure F1 - Photographs Rated using the Questionnaire

8.7 Appendix G – Pilot Study – Questionnaire Responses

Below are the questionnaires completed by the supervisor for photographs 1A to 6A.

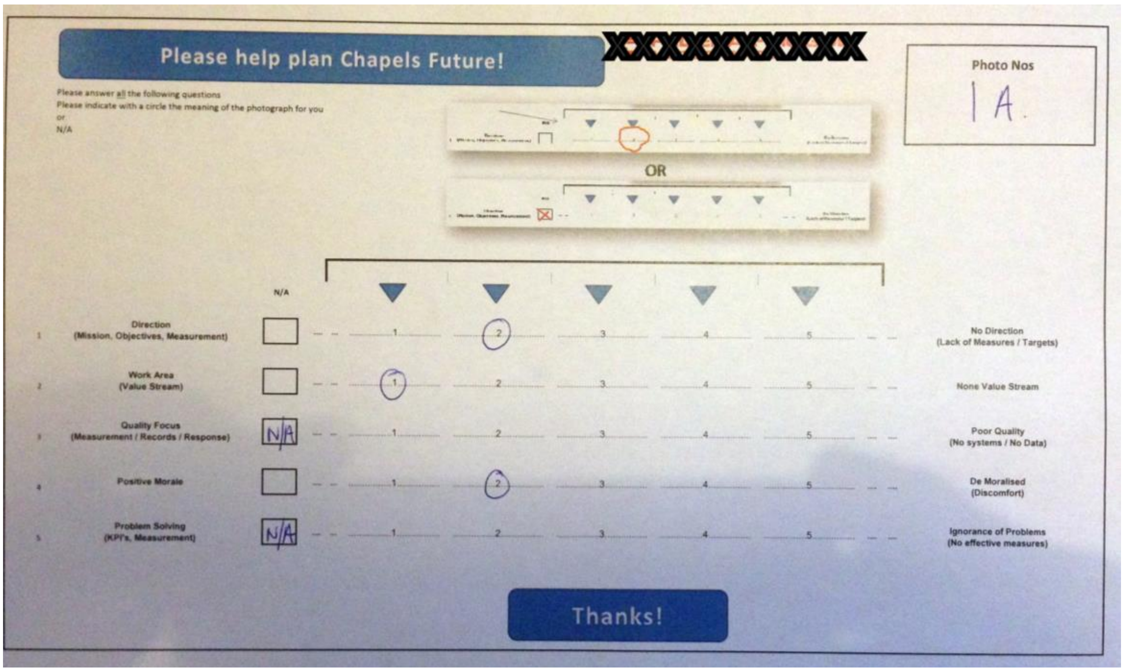


Figure G1 – Pilot Study – Questionnaire Response Photo 1A

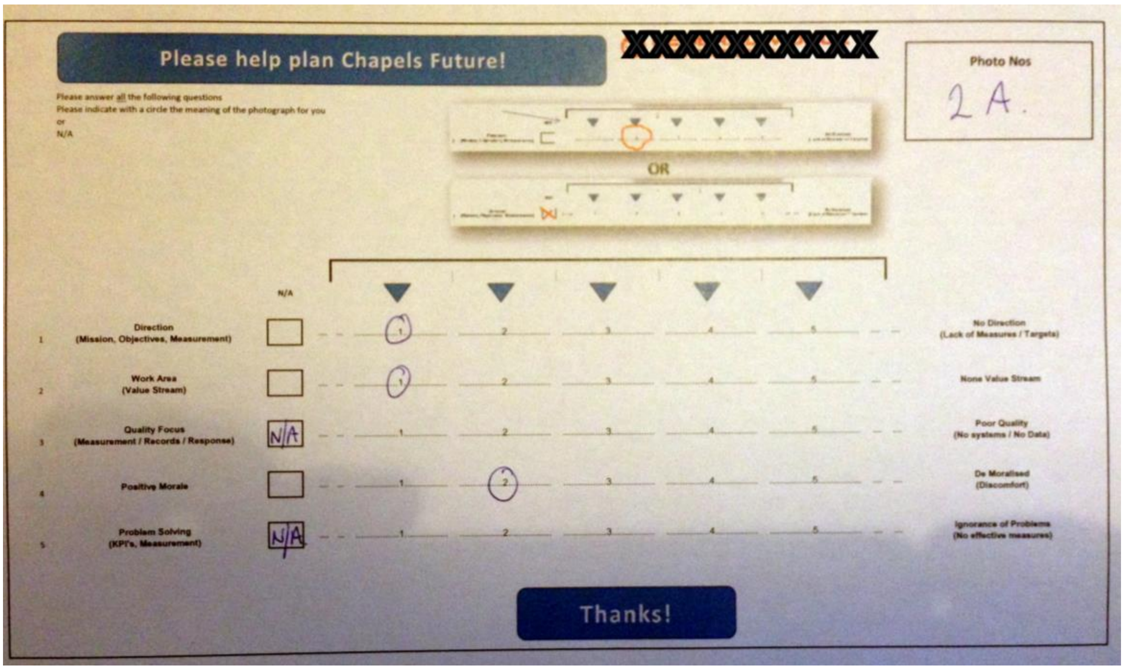


Figure G2 – Pilot Study – Questionnaire Response Photo 2A

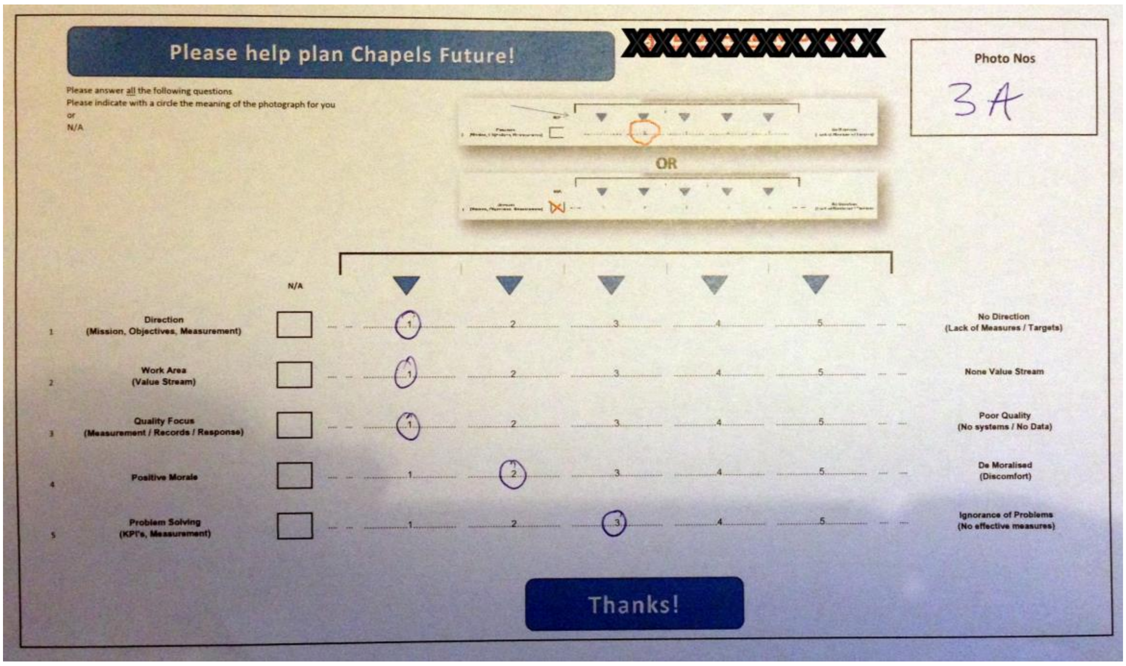


Figure G3 – Pilot Study – Questionnaire Response Photo 3A

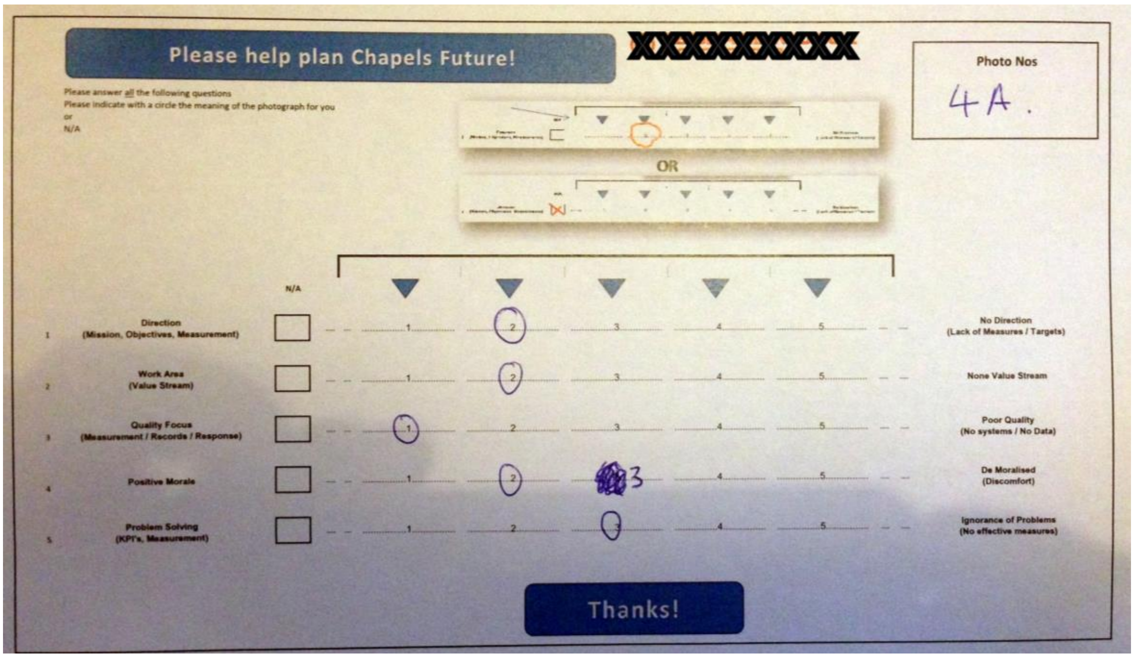


Figure G4 – Pilot Study – Questionnaire Response Photo 4A

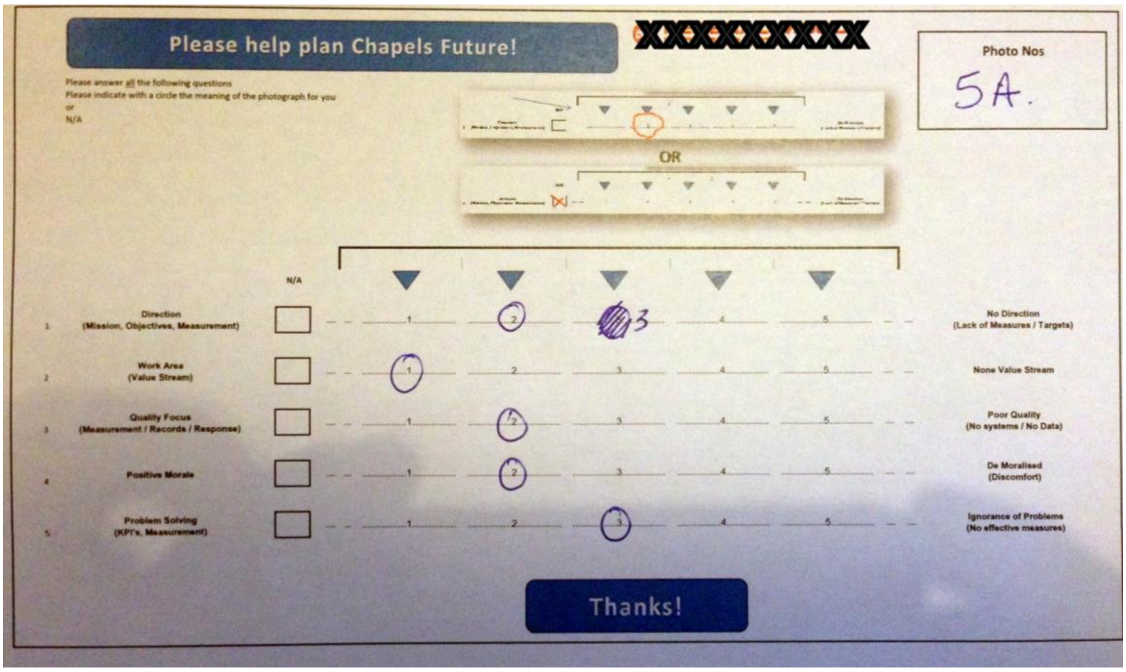


Figure G5 – Pilot Study – Questionnaire Response Photo 5A

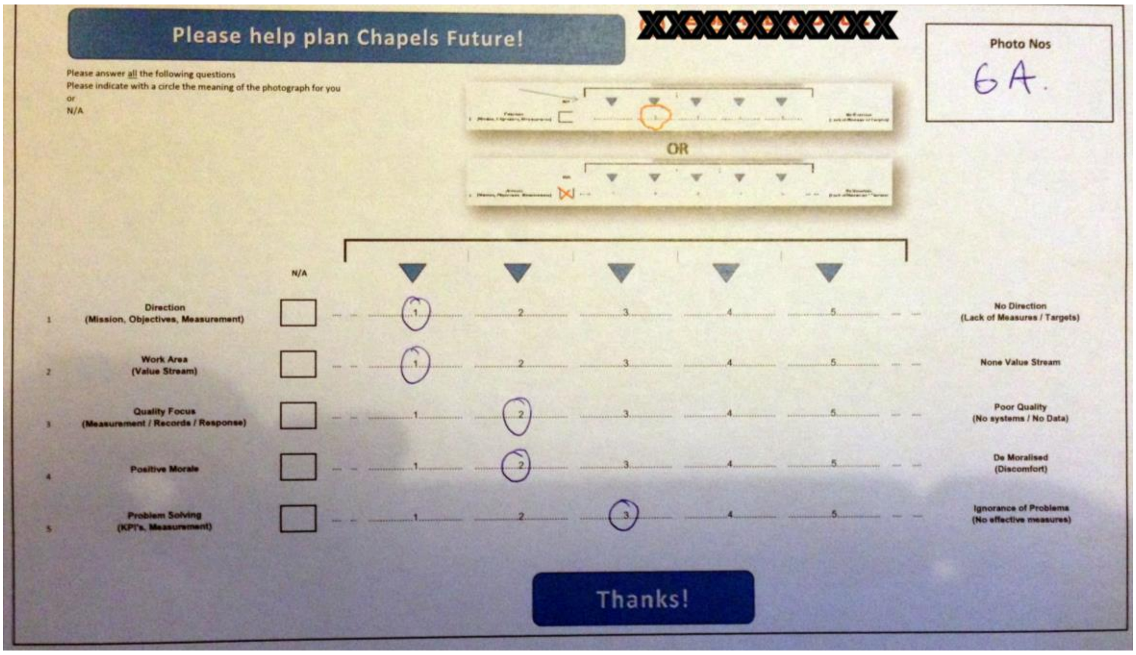


Figure G6 – Pilot Study – Questionnaire Response Photo 6A

8.8 Appendix H – Photographs Used for Photo-Elicitation

Six managers were identified, one from each value stream, for the participant-led-photography method. Each manager captured 12 photographs. These were divided into two groups using the selection process described in Appendix A. Shown below are the six photographs from each of the managers used for their photo-elicitation interviews.

Figure H1 – 6 Photographs used for Elicitation Interview – Manager Nos. 1

Figure H2 – 6 Photographs used for Elicitation Interview – Manager Nos. 2

Figure H3 – 6 Photographs used for Elicitation Interview – Manager Nos. 3

Figure H4 – 6 Photographs used for Elicitation Interview – Manager Nos. 4

Figure H5 – 6 Photographs used for Elicitation Interview – Manager Nos. 5

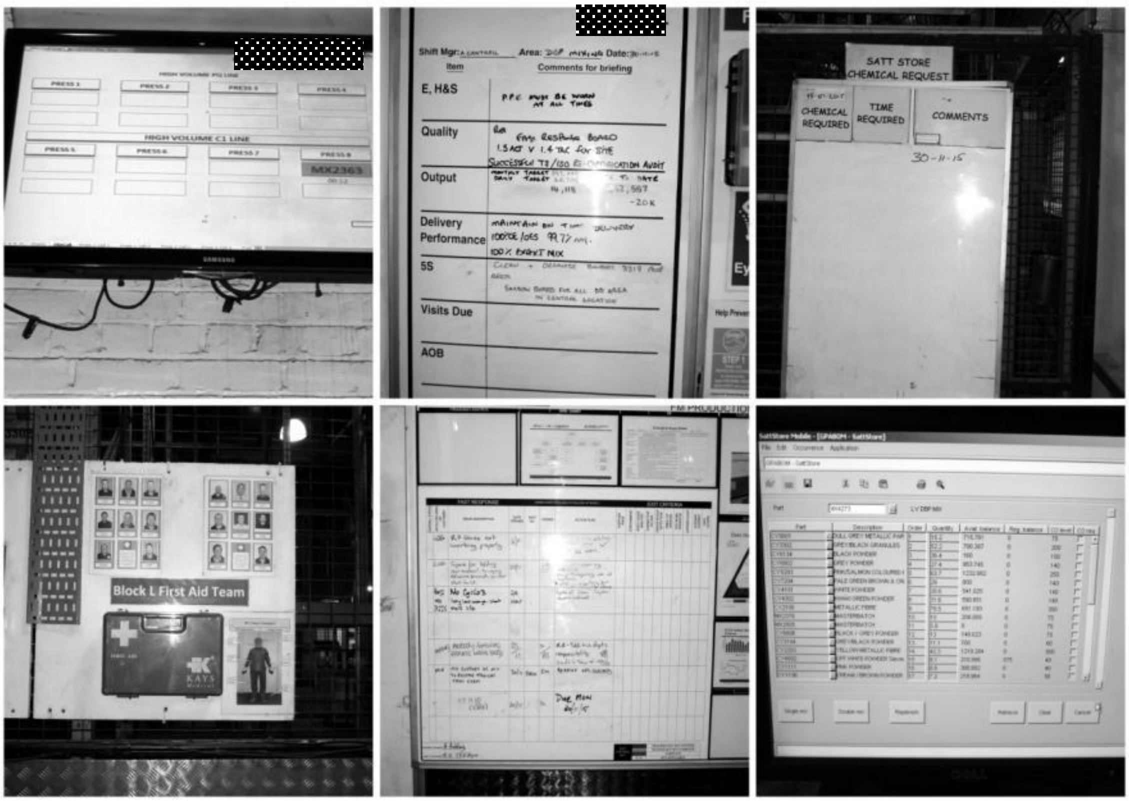


Figure H6 – 6 Photographs used for Elicitation Interview – Manager Nos. 6

8.9 Appendix I – Photo-Elicitation Results from Six Managers

Shown below are each of the twenty pairs of elicited constructs from the six managers. In each case the left hand post-it note records the elicited pole (in response to the 1st question, Appendix B). The middle post-it note records the emergent pole which is in response to the 2nd question shown in Appendix B. The right hand post-it note records the comments made in addition to the elicitation comments. This is soft data that was collected for potential use to contextualise the construct comments.

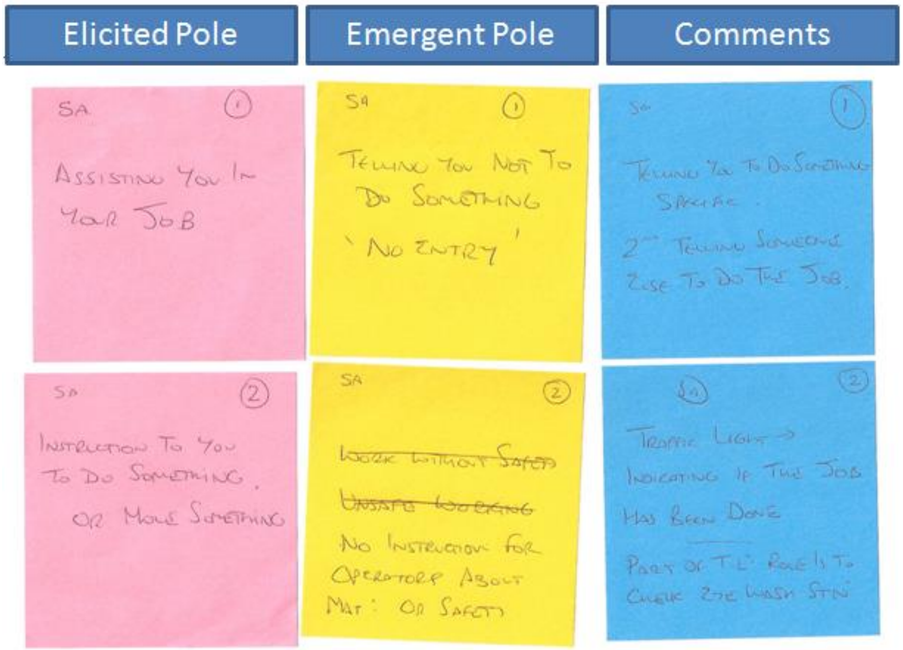


Figure I1 – Results of Photo-Elicitation – Triadic Sets 1 & 2 – Manager Nos. 1

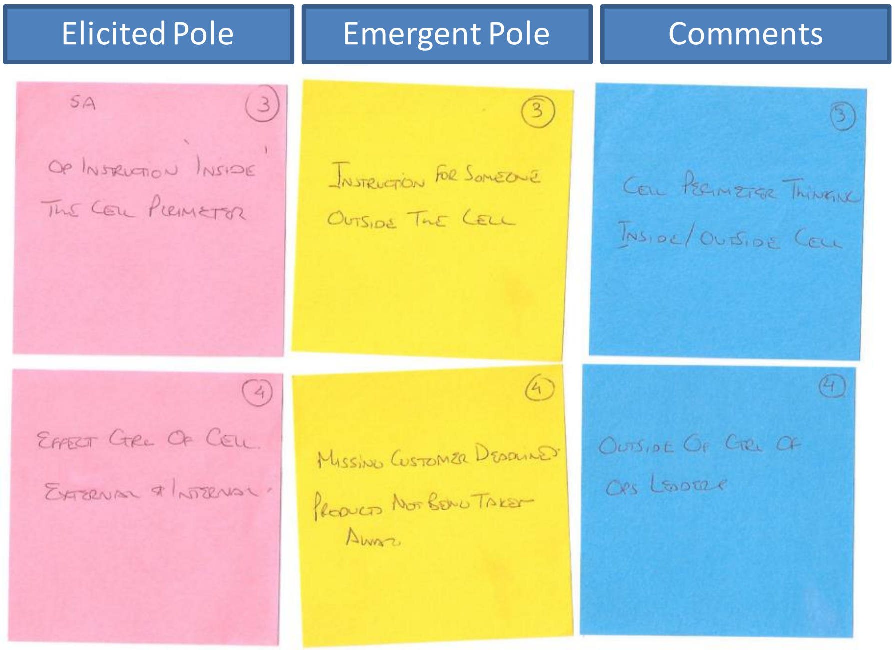


Figure I2 – Results of Photo-Elicitation – Triadic Sets 3 & 4 – Manager Nos. 1

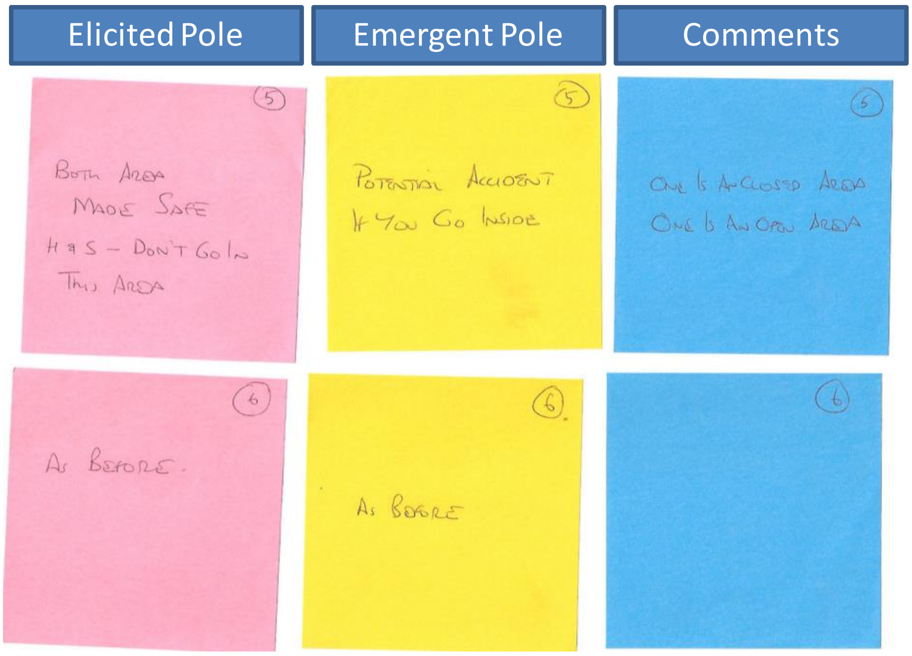


Figure I3 – Results of Photo-Elicitation – Triadic Sets 5 & 6 – Manager Nos. 1

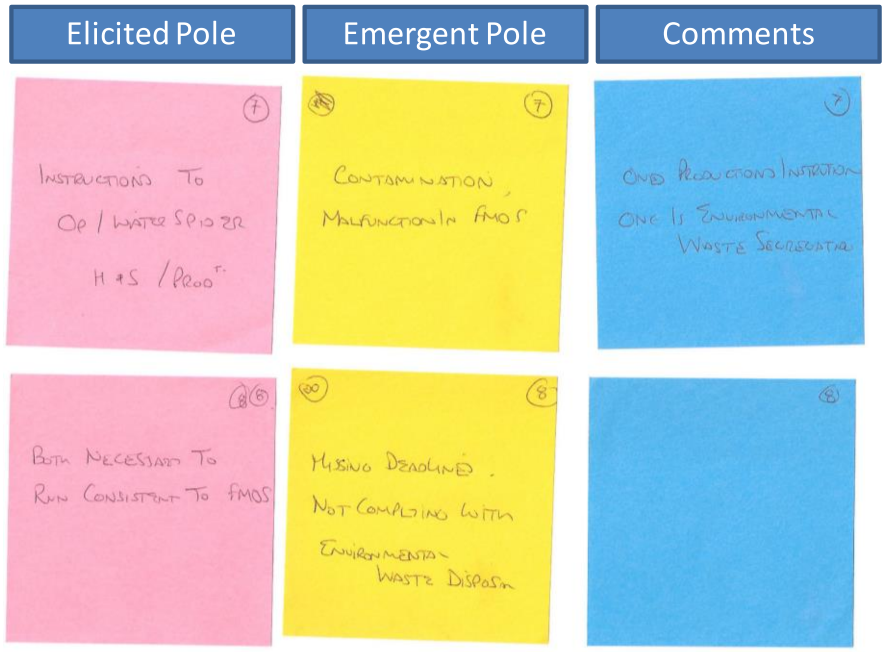


Figure I4 – Results of Photo-Elicitation – Triadic Sets 7 & 8 – Manager Nos. 1

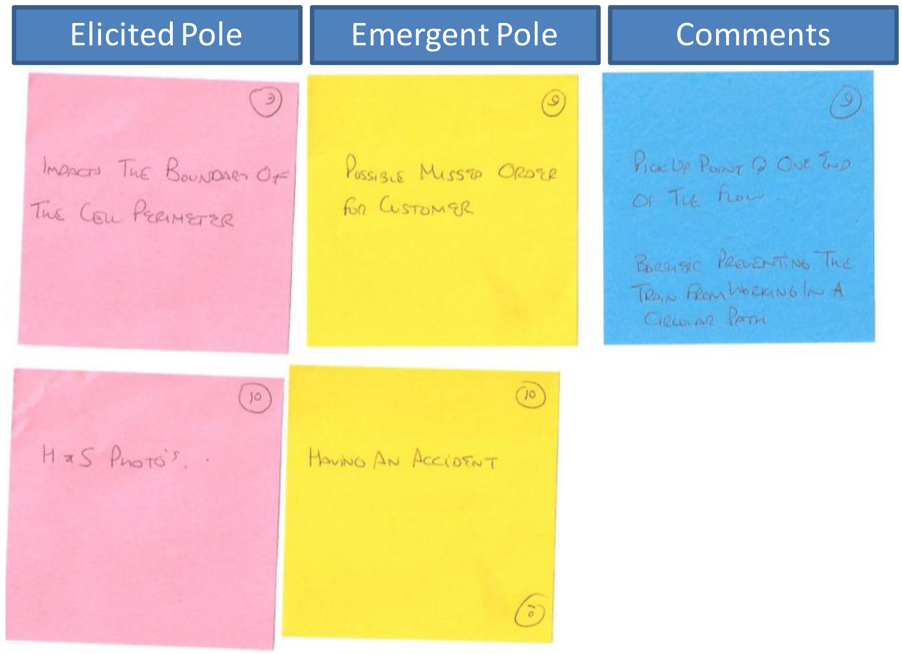


Figure I5 – Results of Photo-Elicitation – Triadic Sets 9 & 10 – Manager Nos. 1

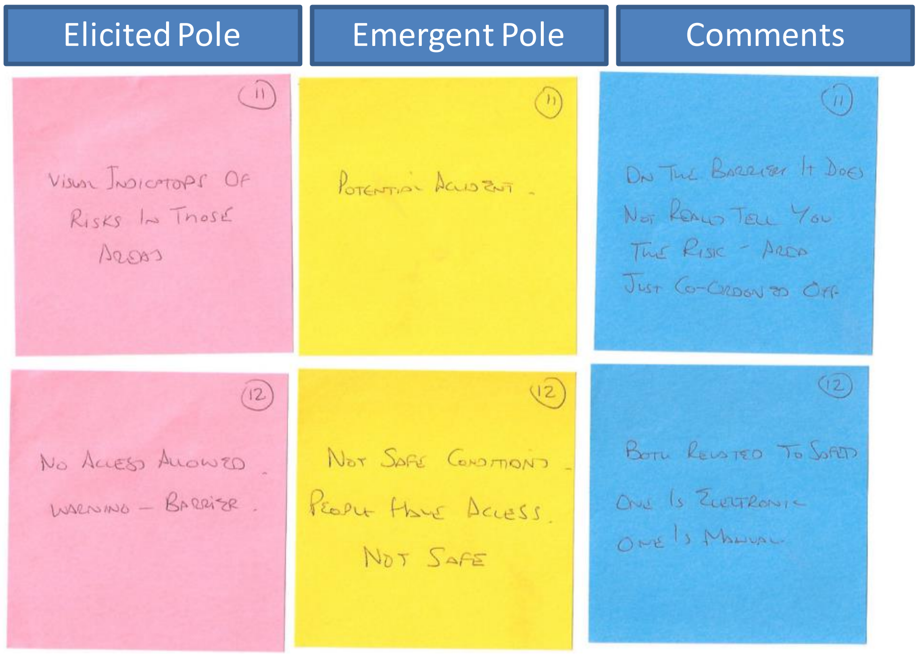


Figure I6 – Results of Photo-Elicitation – Triadic Sets 11 & 12 – Manager Nos. 1

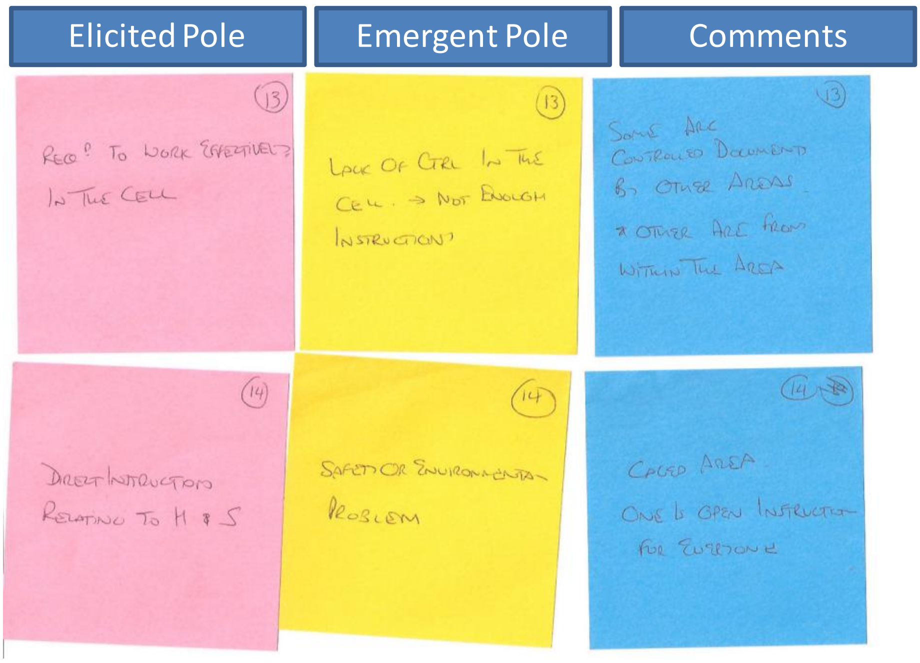


Figure I7 – Results of Photo-Elicitation – Triadic Sets 13 & 14 – Manager Nos. 1

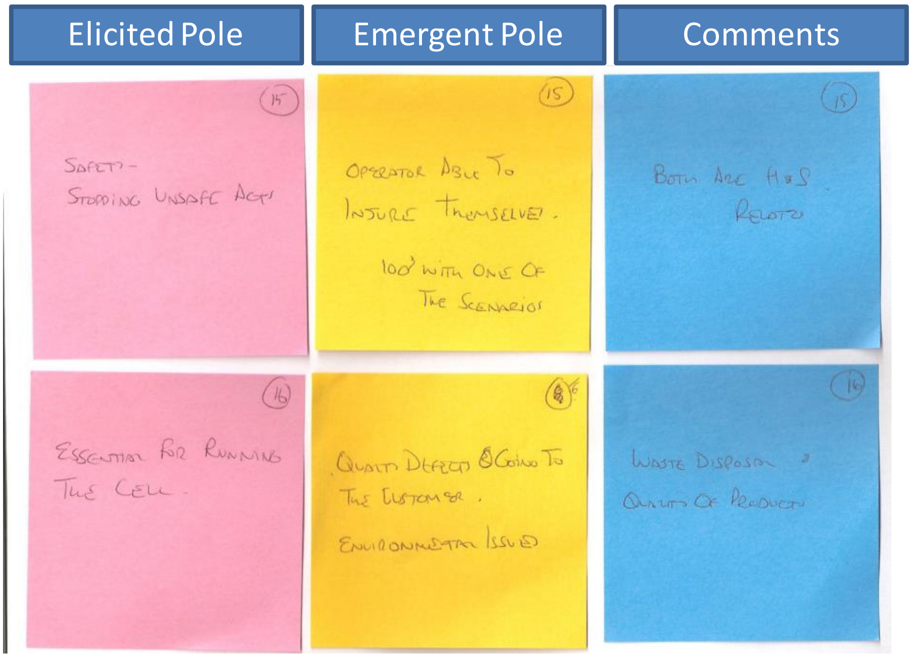


Figure I8 – Results of Photo-Elicitation – Triadic Sets 15 & 16 – Manager Nos. 1

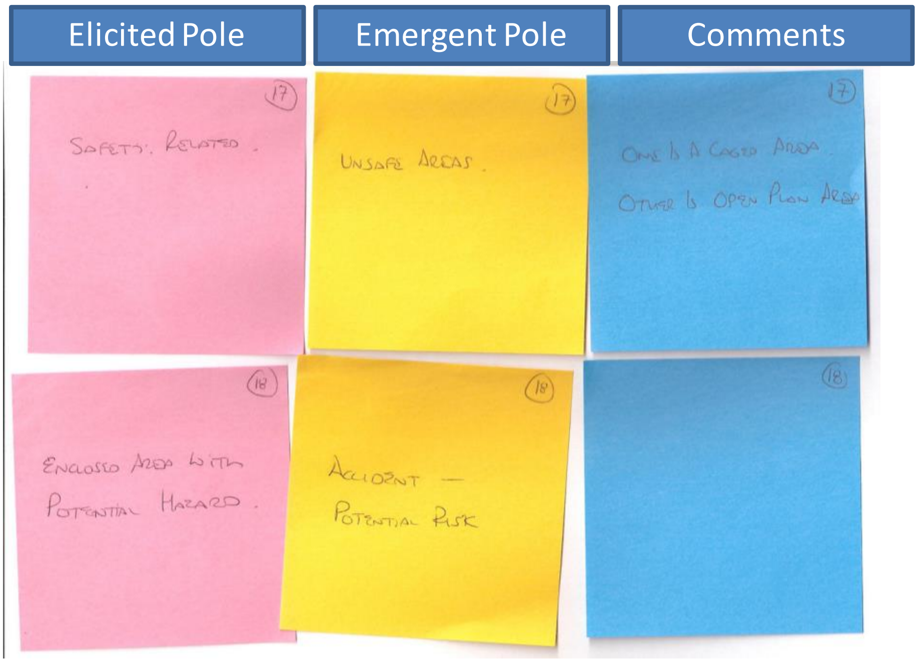


Figure I9 – Results of Photo-Elicitation – Triadic Sets 17 & 18 – Manager Nos. 1

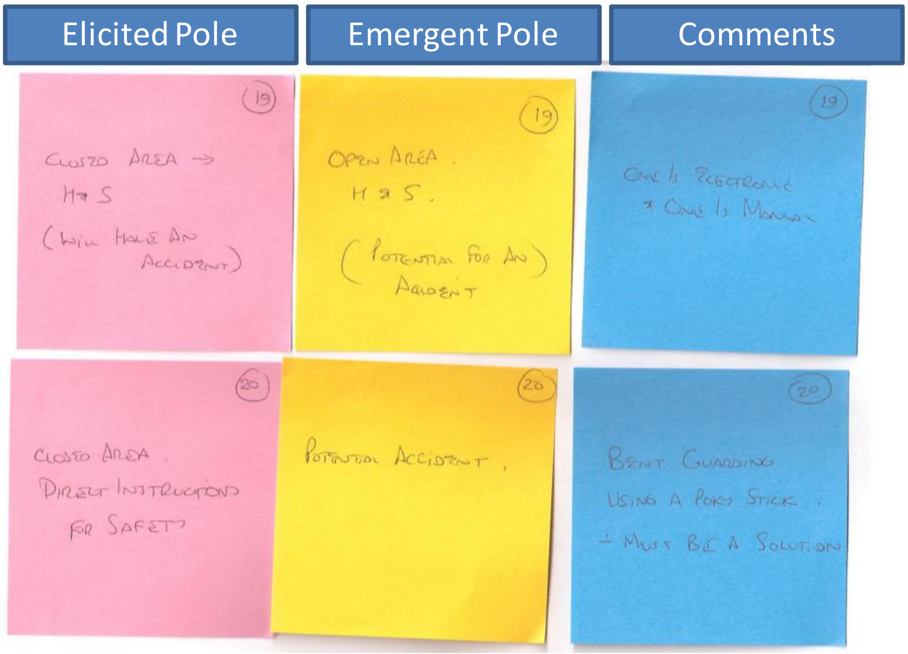


Figure I10 – Results of Photo-Elicitation – Triadic Sets 19 & 20 – Manager Nos. 1

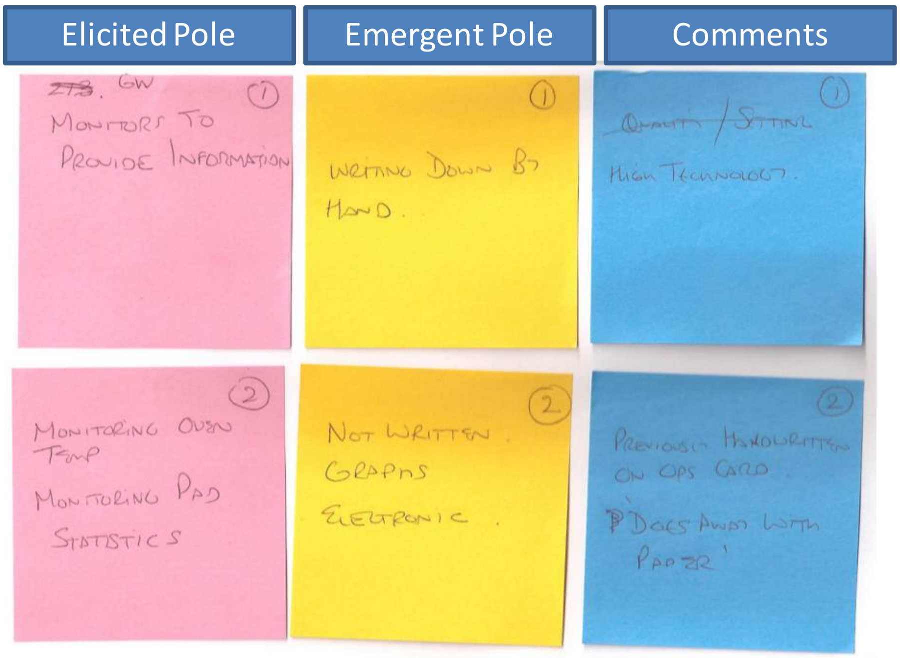


Figure I11 – Results of Photo-Elicitation – Triadic Sets 1 & 2 – Manager Nos. 2

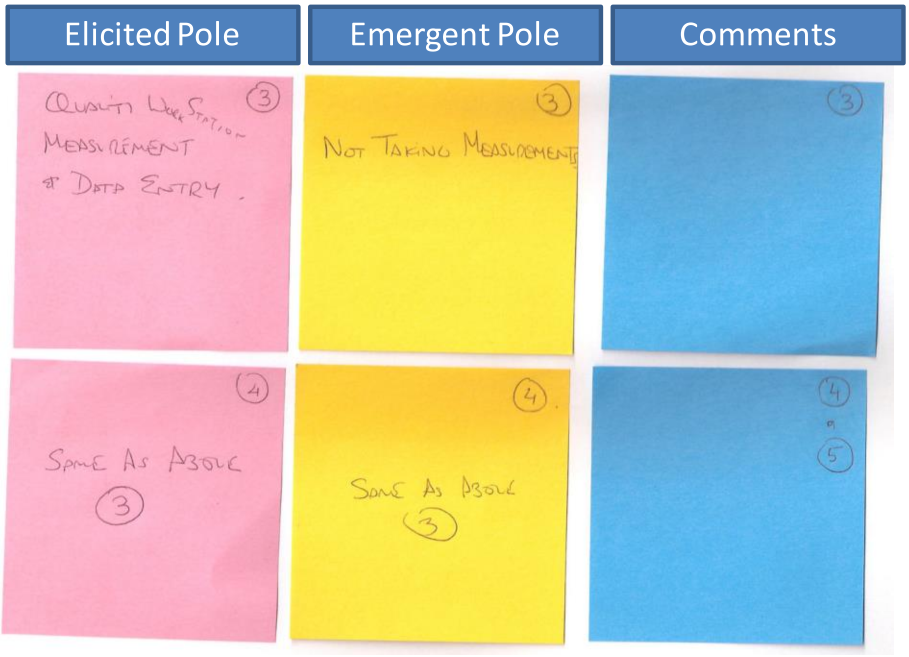


Figure I12 – Results of Photo-Elicitation – Triadic Sets 3 & 4 – Manager Nos. 2

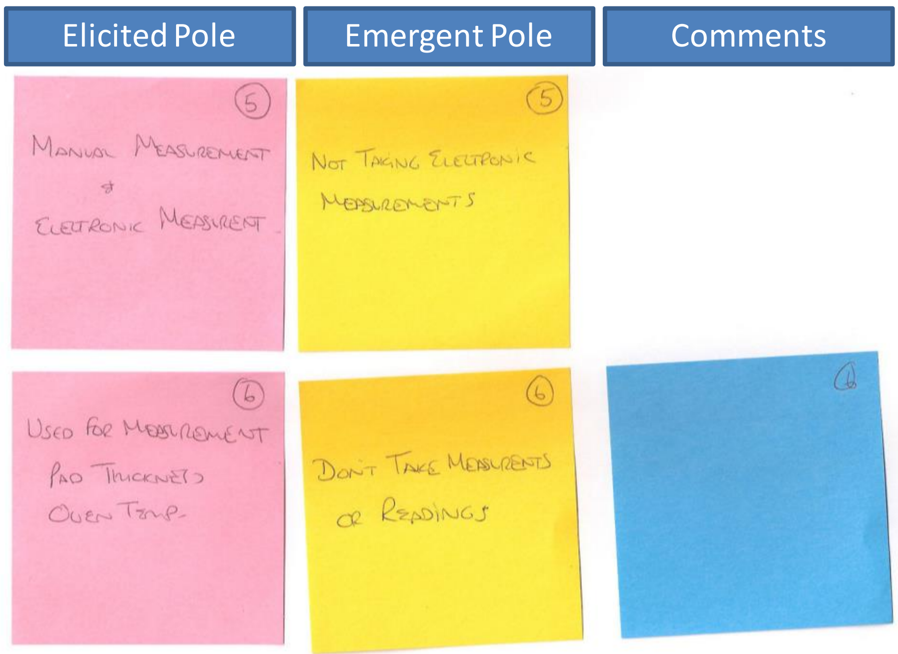


Figure I13 – Results of Photo-Elicitation – Triadic Sets 5 & 6 – Manager Nos. 2

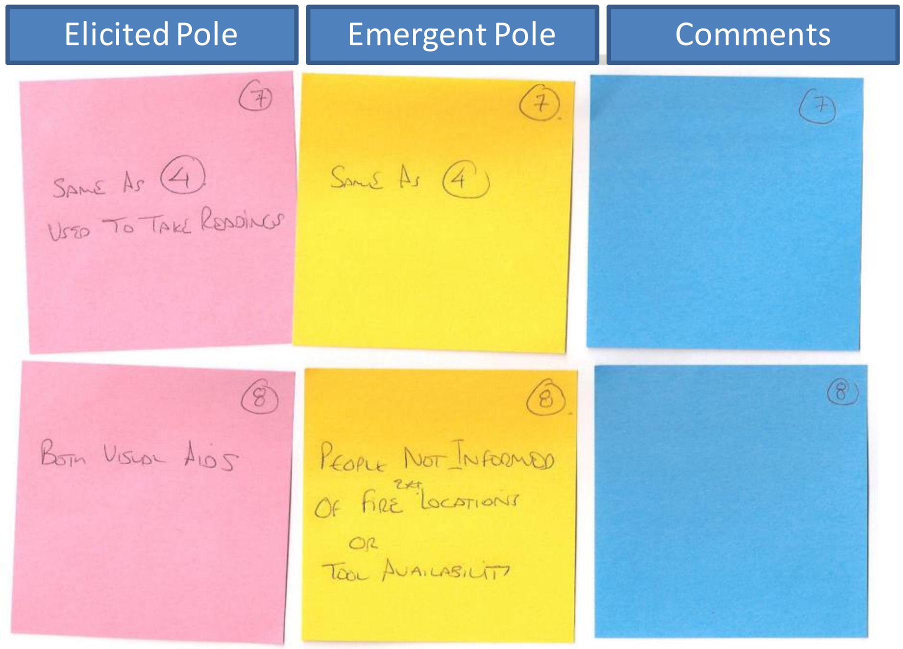


Figure I14 – Results of Photo-Elicitation – Triadic Sets 7 & 8 – Manager Nos. 2

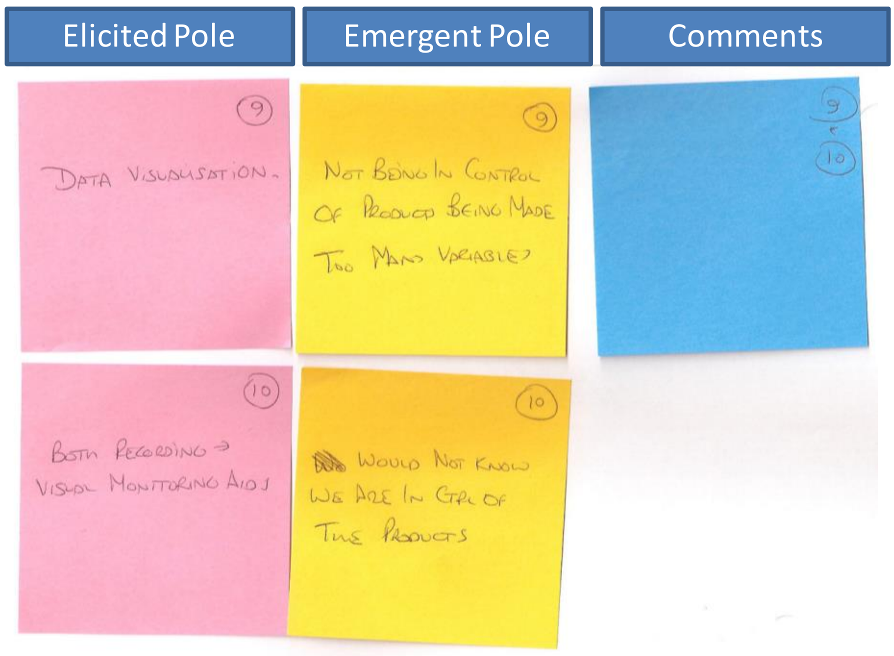


Figure I15 – Results of Photo-Elicitation – Triadic Sets 9 & 10 – Manager Nos. 2

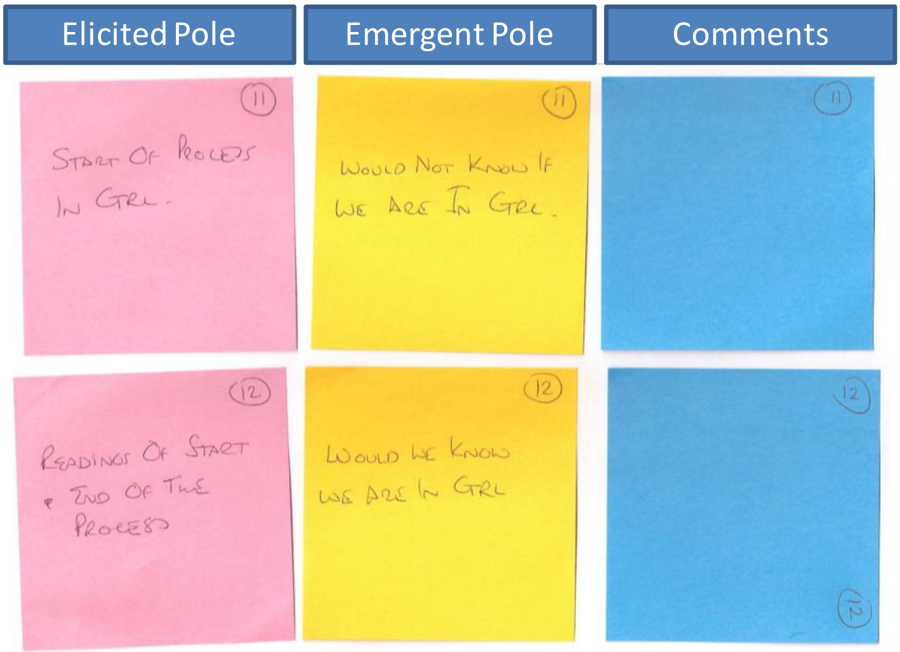


Figure I16 – Results of Photo-Elicitation – Triadic Sets 11 & 12 – Manager Nos. 2

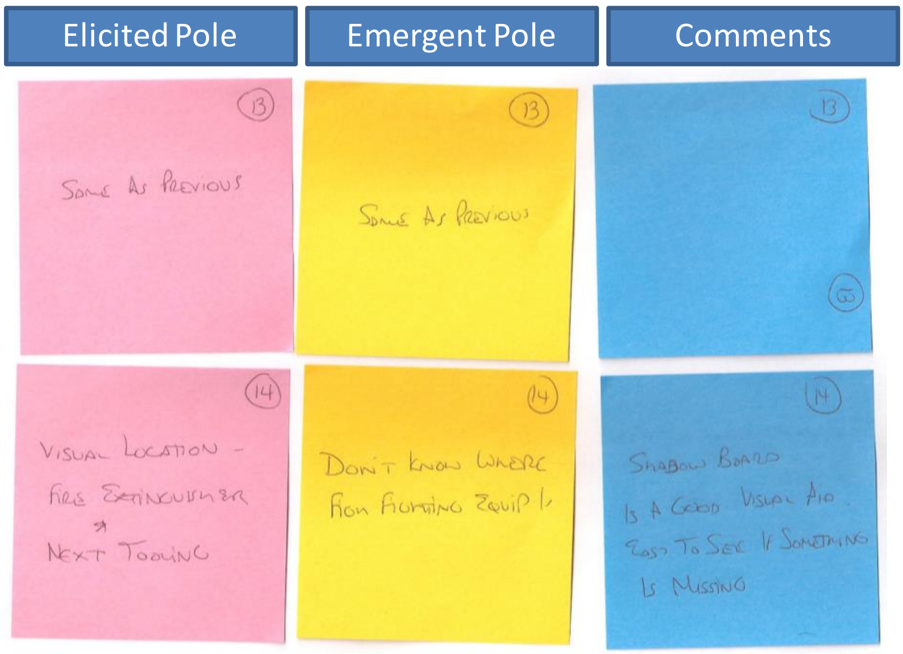


Figure I17 – Results of Photo-Elicitation – Triadic Sets 13 & 14 – Manager Nos. 2

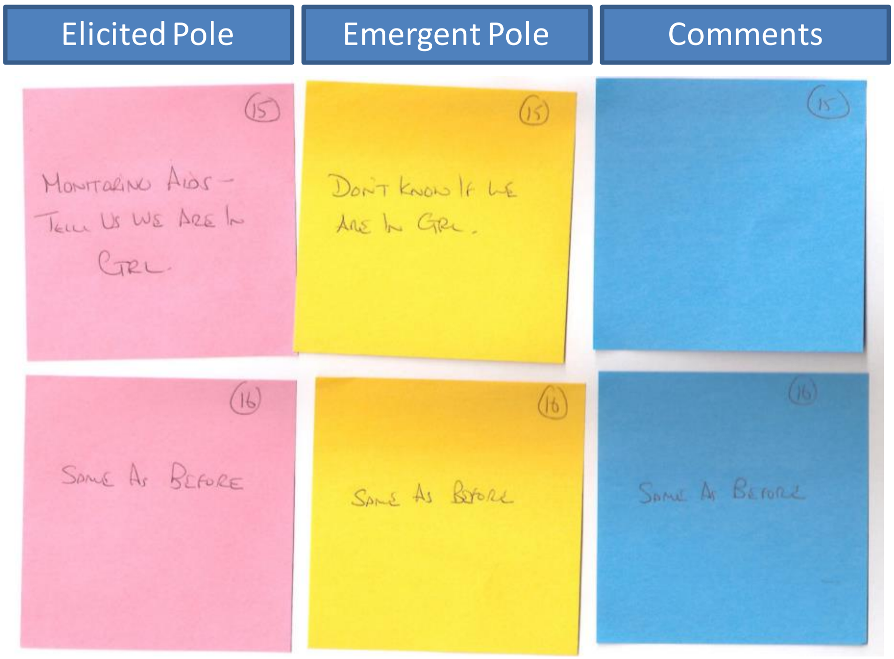


Figure I18 – Results of Photo-Elicitation – Triadic Sets 15 & 16 – Manager Nos. 2

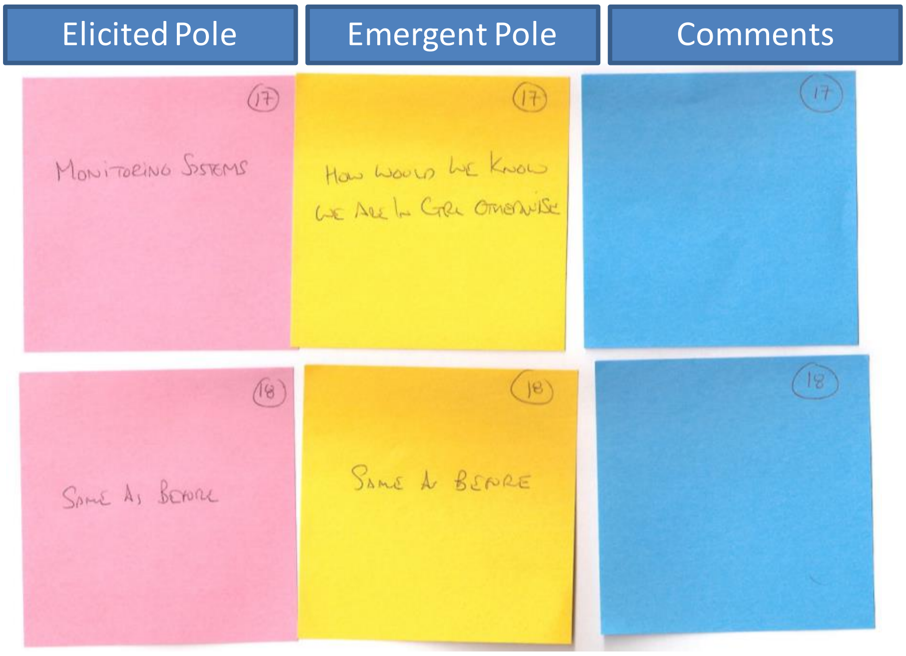


Figure I19 – Results of Photo-Elicitation – Triadic Sets 17 & 18 – Manager Nos. 2

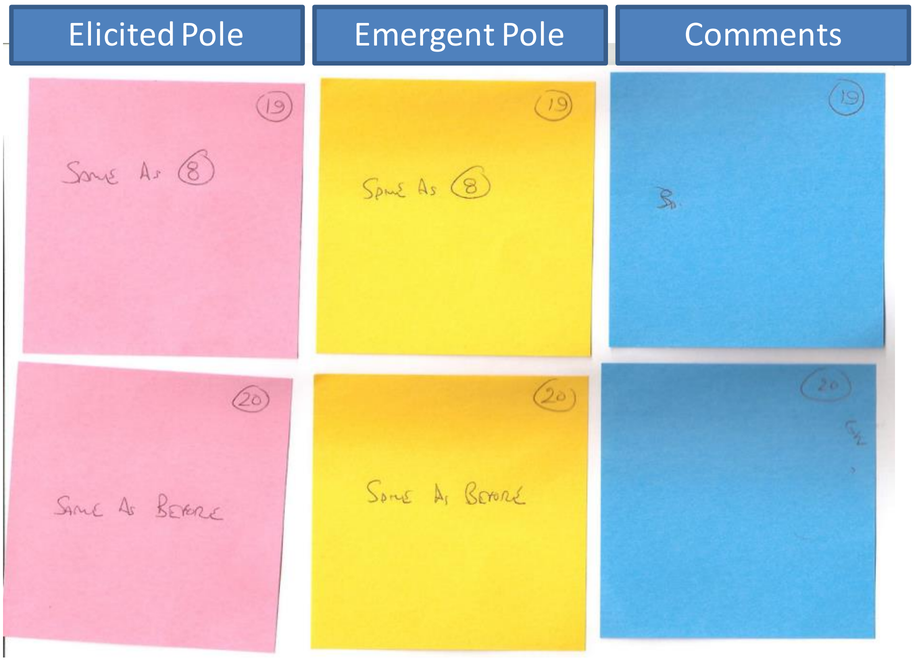


Figure I20 – Results of Photo-Elicitation – Triadic Sets 19 & 20 – Manager Nos. 2

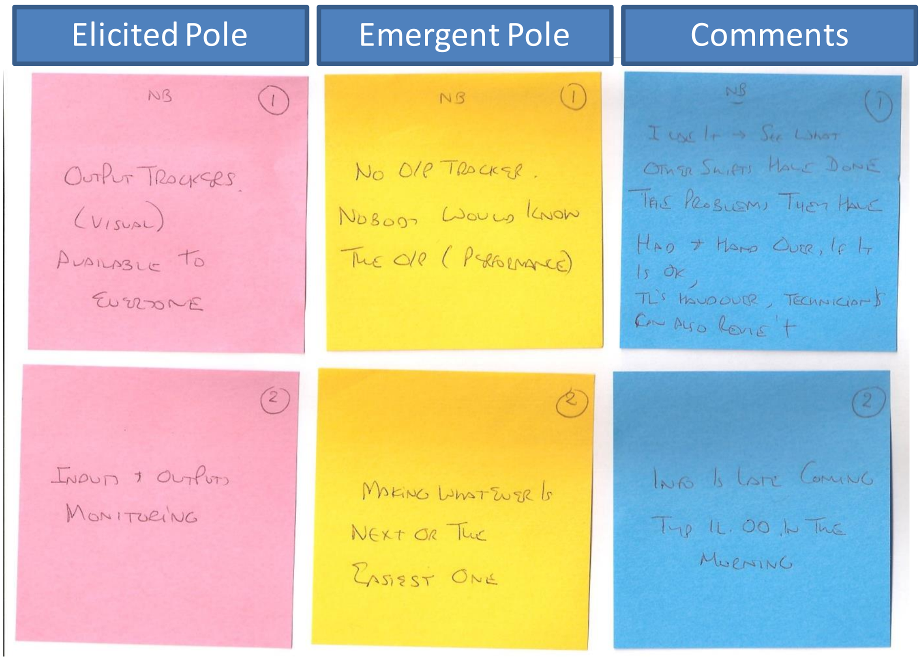


Figure I21 – Results of Photo-Elicitation – Triadic Sets 1 & 2 – Manager Nos. 3

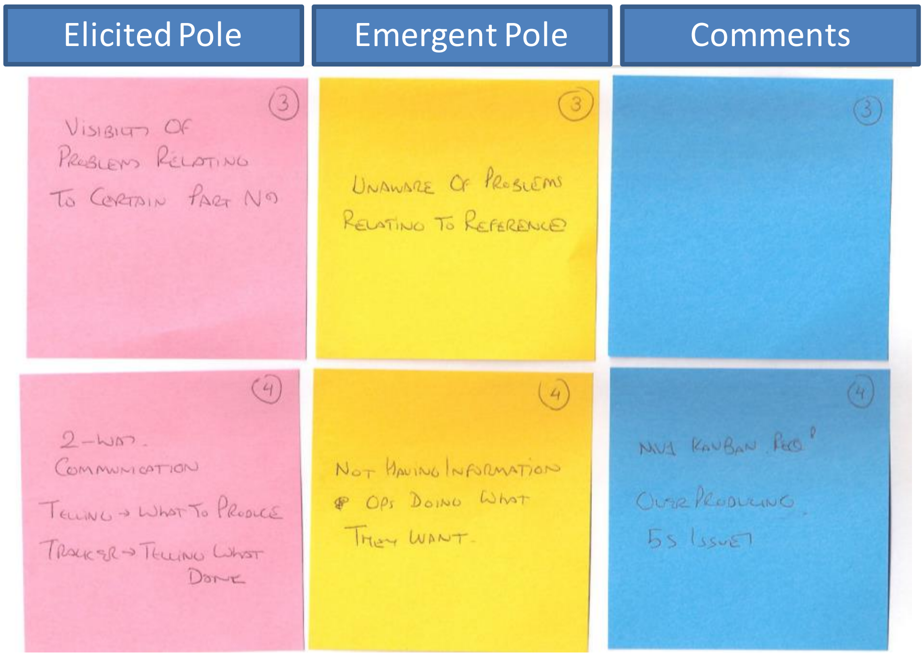


Figure I22 – Results of Photo-Elicitation – Triadic Sets 3 & 4 – Manager Nos. 3

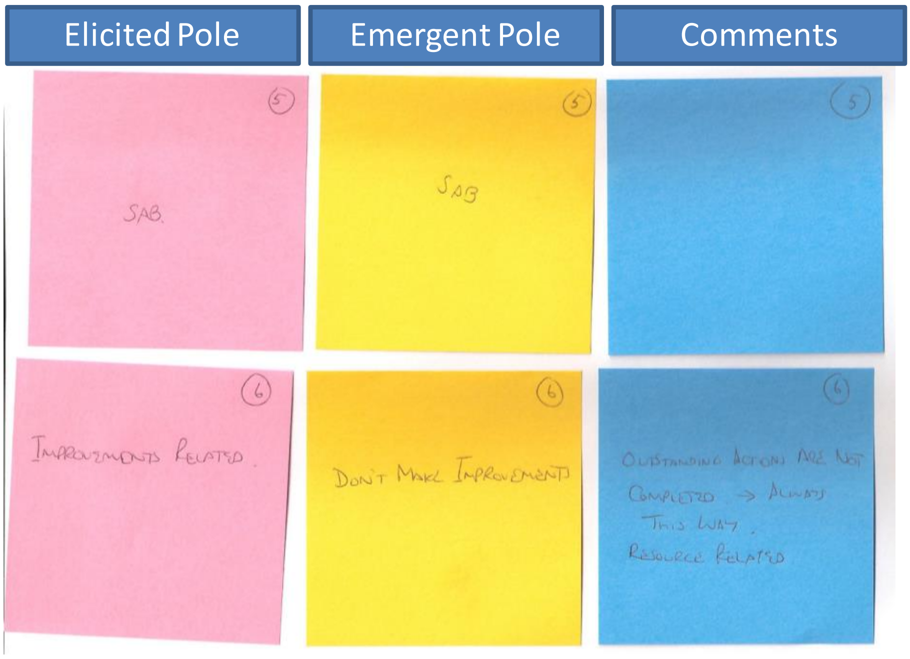


Figure I23 – Results of Photo-Elicitation – Triadic Sets 5 & 6 – Manager Nos. 3

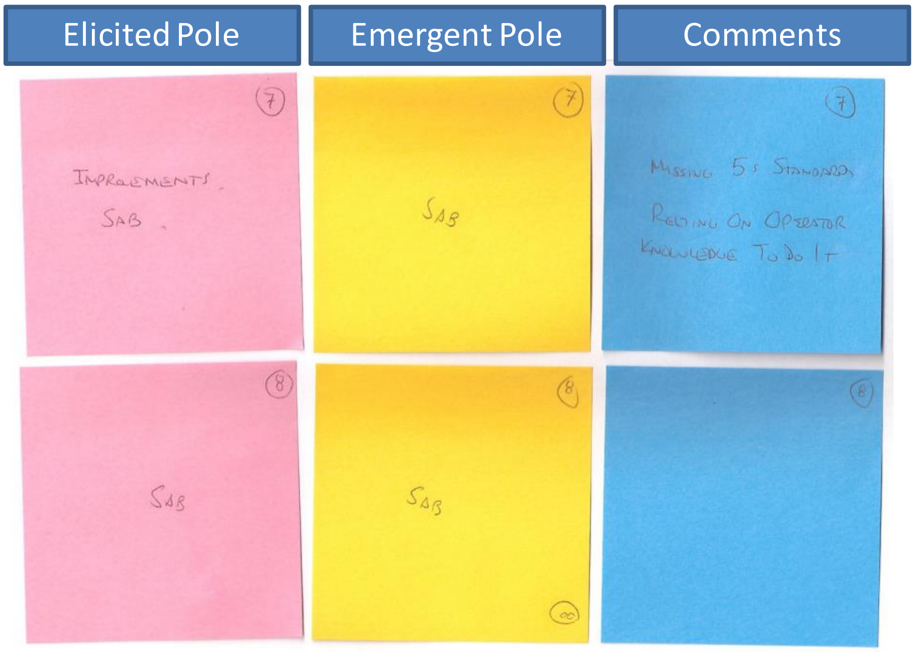


Figure I24 – Results of Photo-Elicitation – Triadic Sets 7 & 8 – Manager Nos. 3

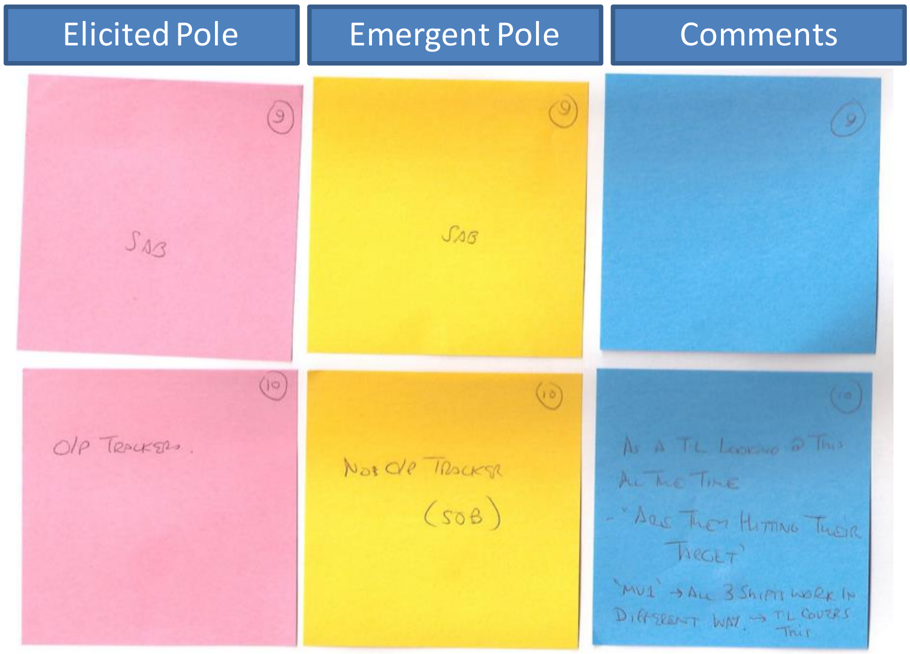


Figure I25 – Results of Photo-Elicitation – Triadic Sets 9 & 10 – Manager Nos. 3

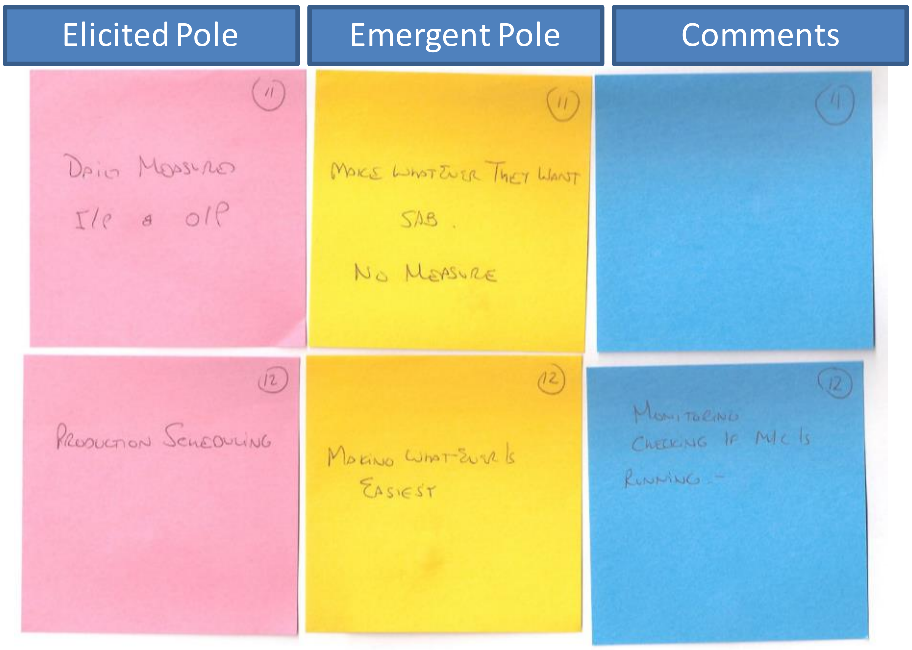


Figure I26 – Results of Photo-Elicitation – Triadic Sets 11 & 12 – Manager Nos. 3

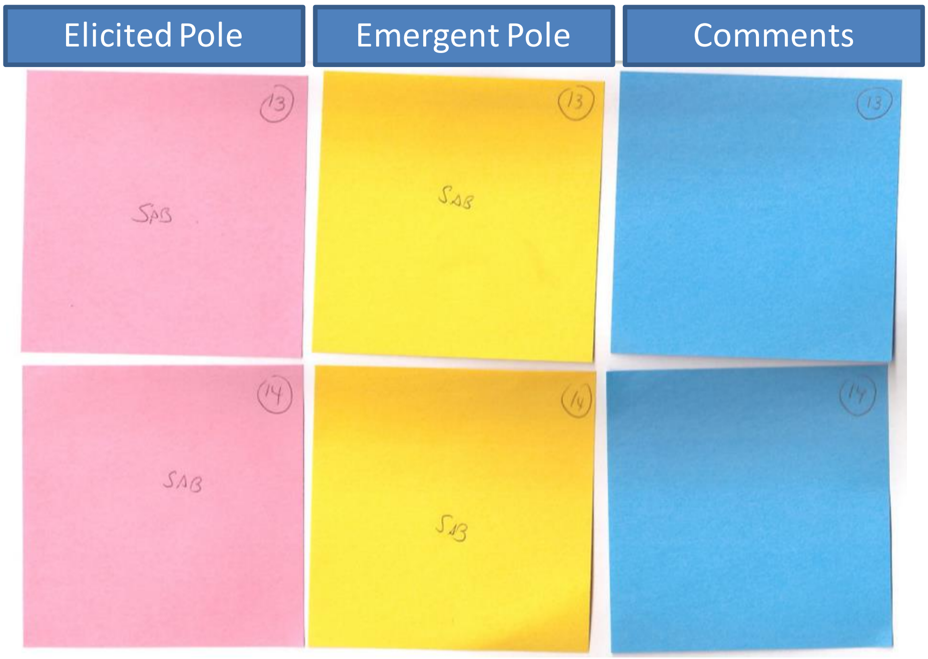


Figure I27 – Results of Photo-Elicitation – Triadic Sets 13 & 14 – Manager Nos. 3

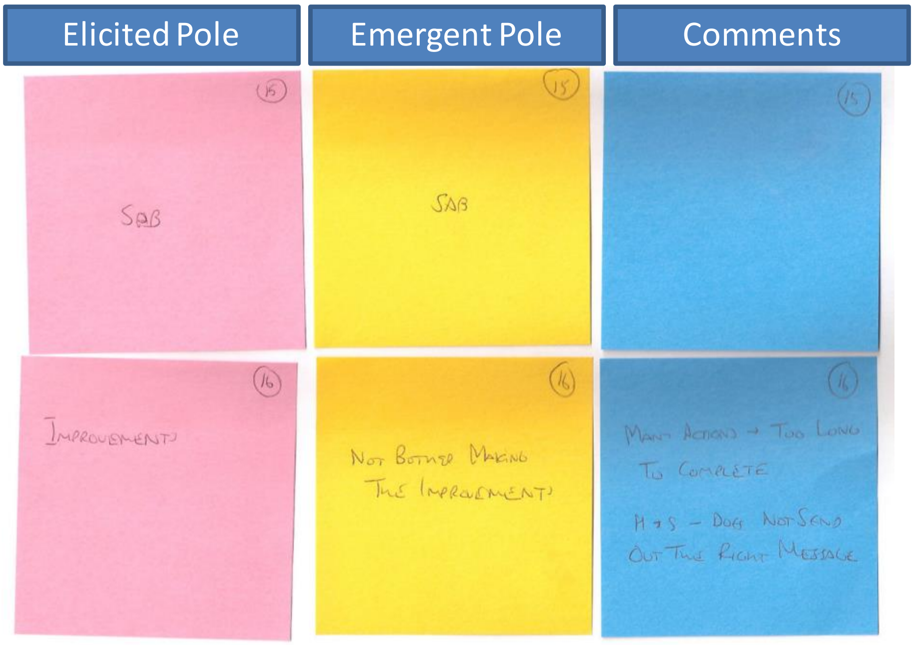


Figure I28 – Results of Photo-Elicitation – Triadic Sets 15 & 16 – Manager Nos. 3

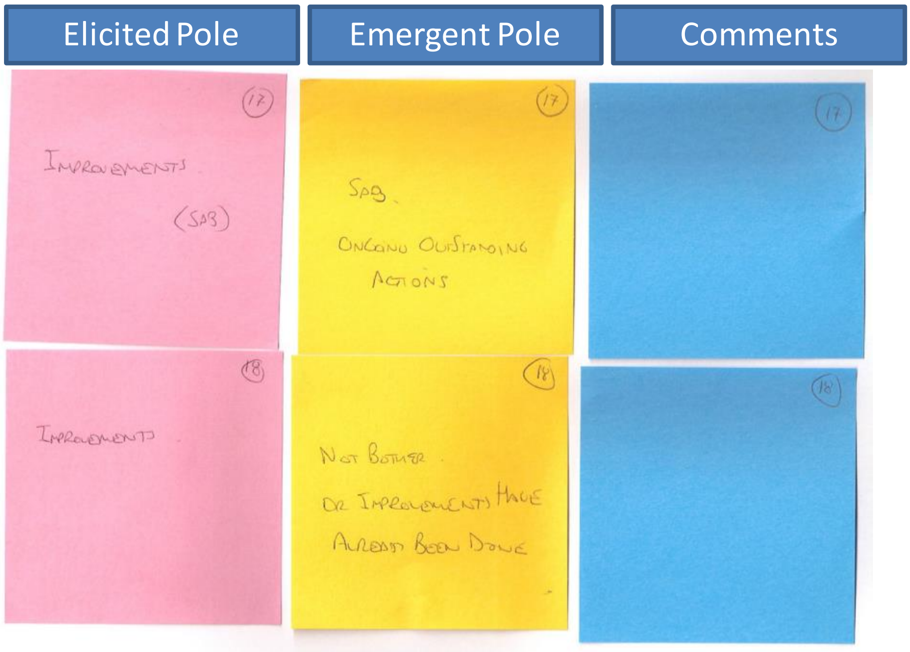


Figure I29 – Results of Photo-Elicitation – Triadic Sets 17 & 18 – Manager Nos. 3

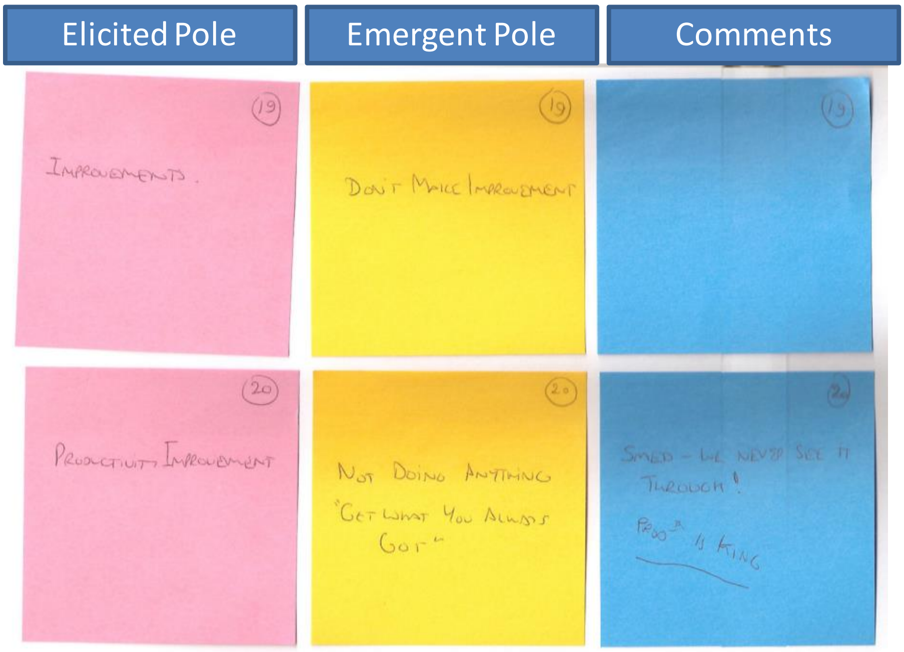


Figure I30 – Results of Photo-Elicitation – Triadic Sets 19 & 20 – Manager Nos. 3

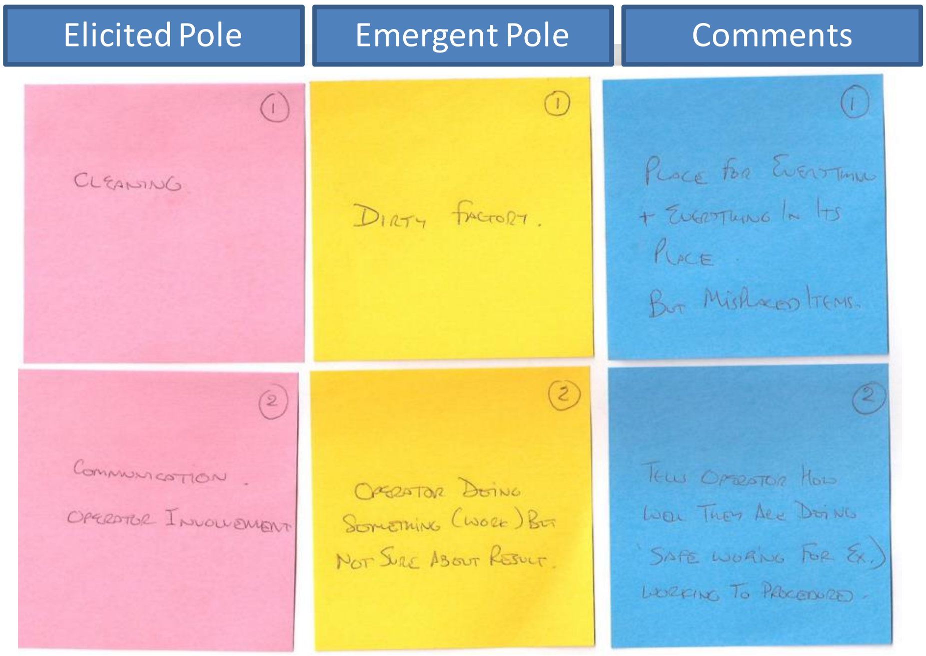


Figure I31 – Results of Photo-Elicitation – Triadic Sets 1 & 2 – Manager Nos. 4

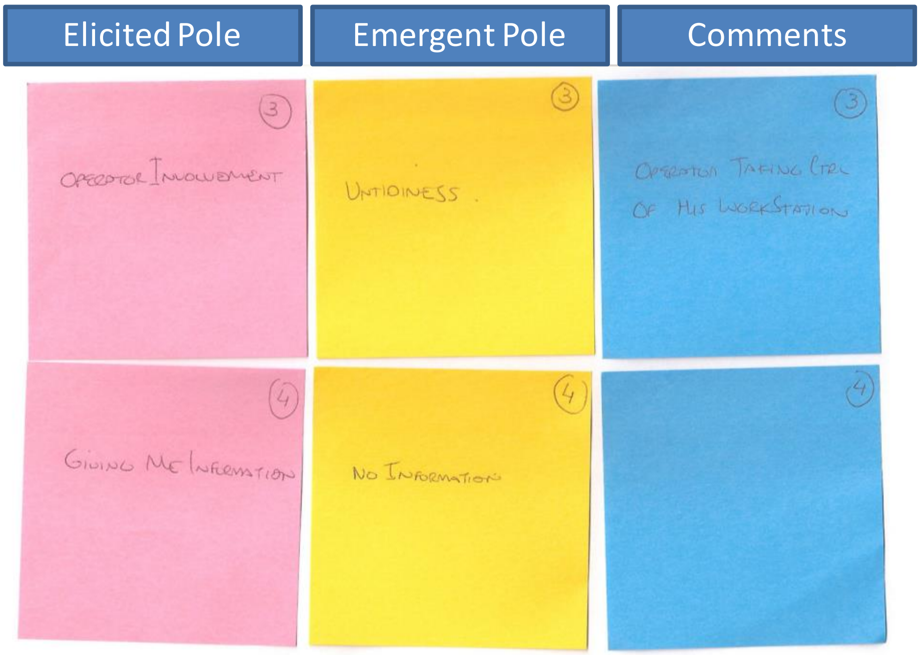


Figure I32 – Results of Photo-Elicitation – Triadic Sets 3 & 4 – Manager Nos. 4

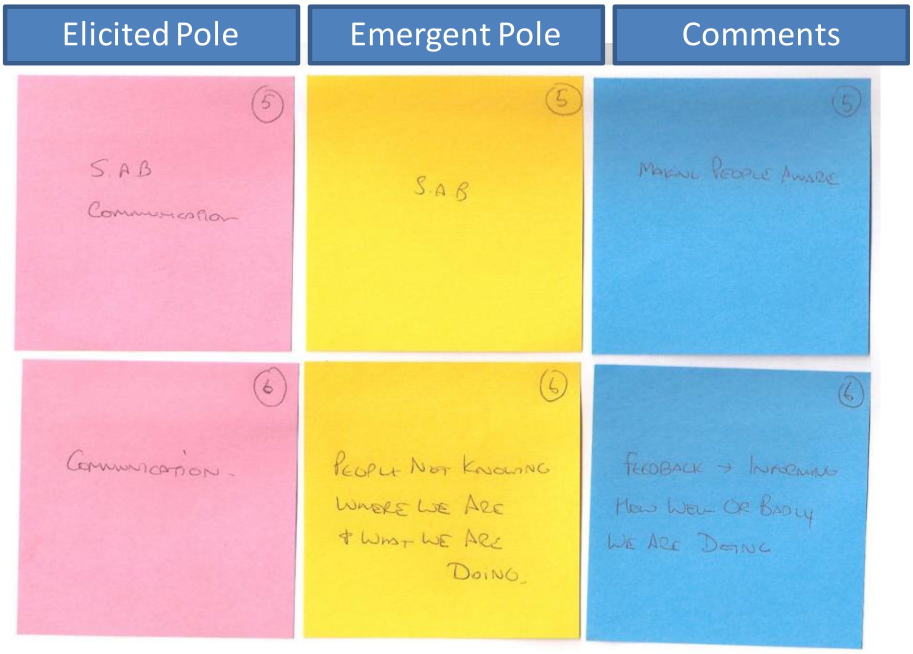


Figure I33 – Results of Photo-Elicitation – Triadic Sets 5 & 6 – Manager Nos. 4

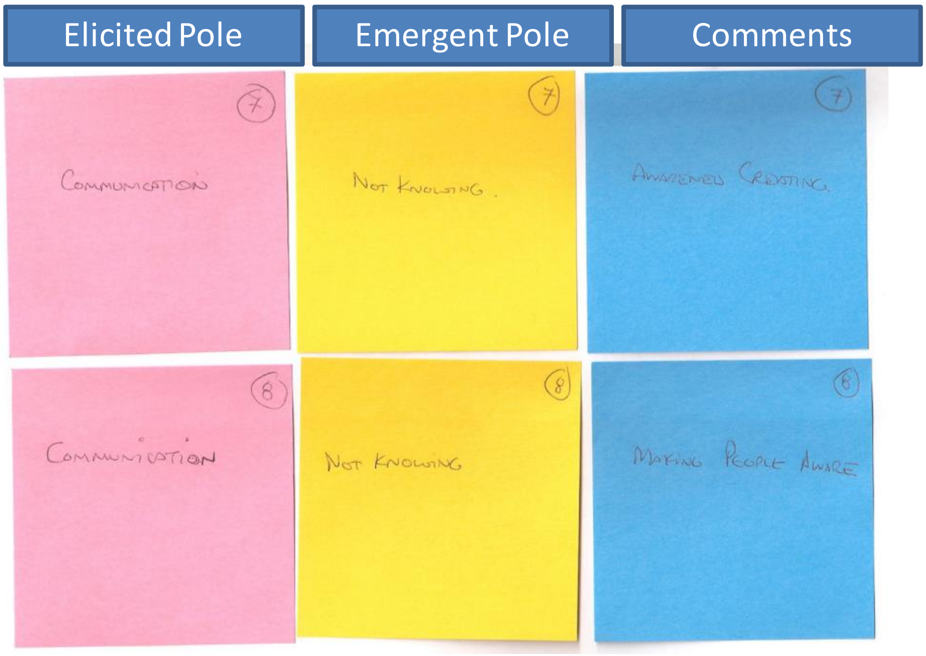


Figure I34 – Results of Photo-Elicitation – Triadic Sets 7 & 8 – Manager Nos. 4

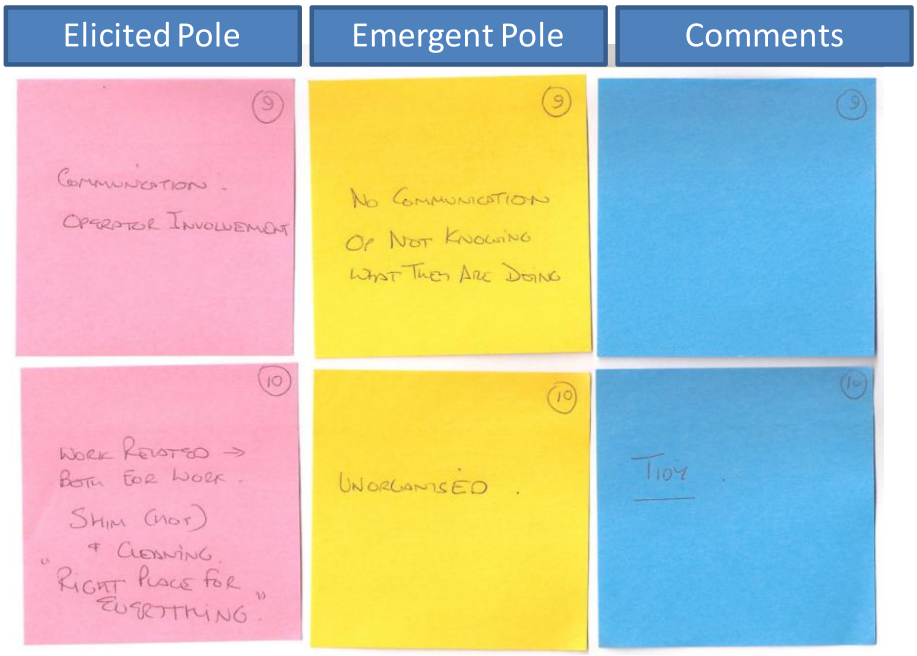


Figure I35 – Results of Photo-Elicitation – Triadic Sets 9 & 10 – Manager Nos. 4

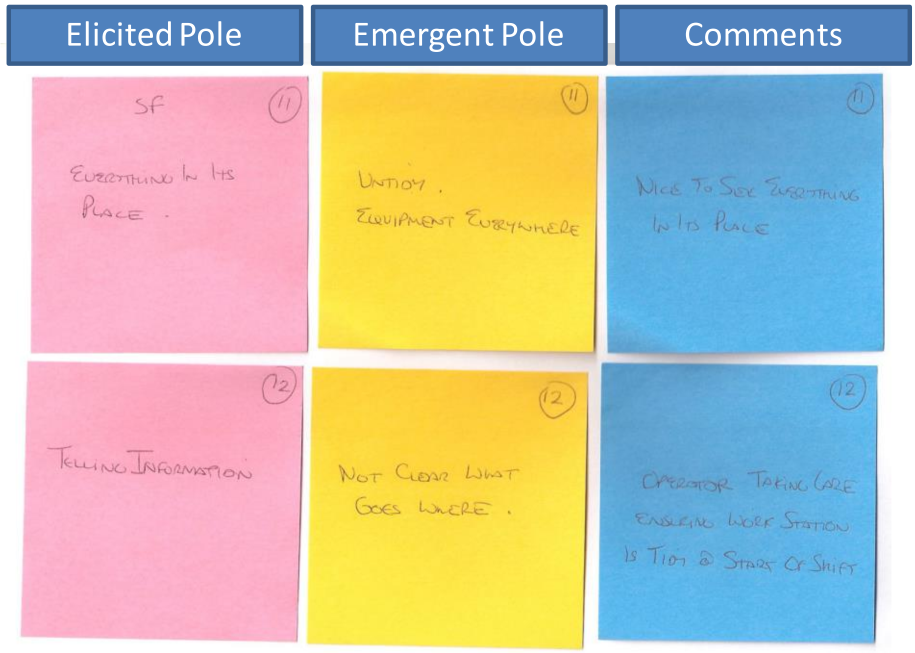


Figure I36 – Results of Photo-Elicitation – Triadic Sets 11 & 12 – Manager Nos. 4

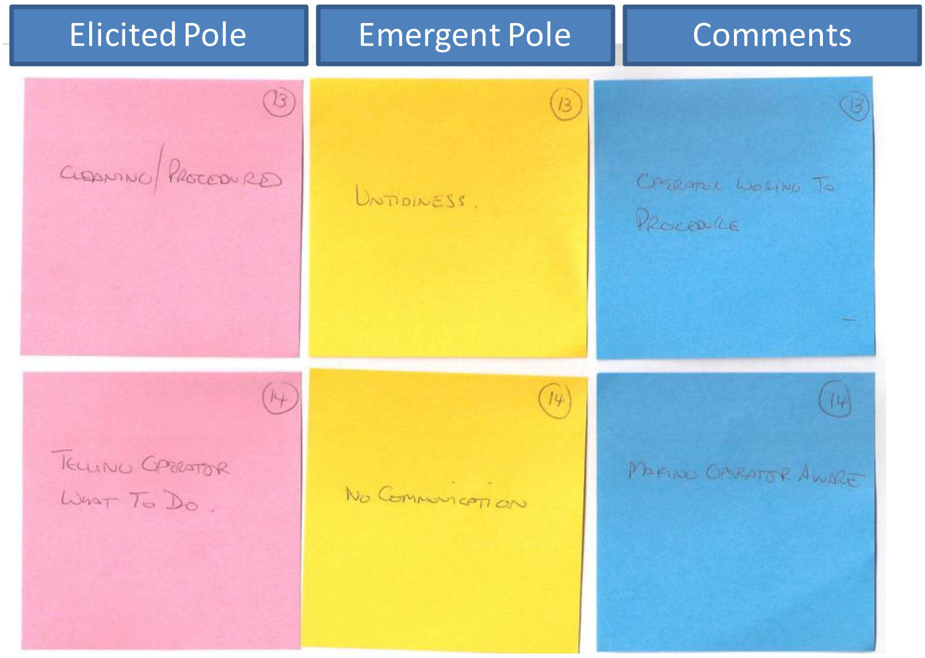


Figure I37 – Results of Photo-Elicitation – Triadic Sets 13 & 14 – Manager Nos. 4

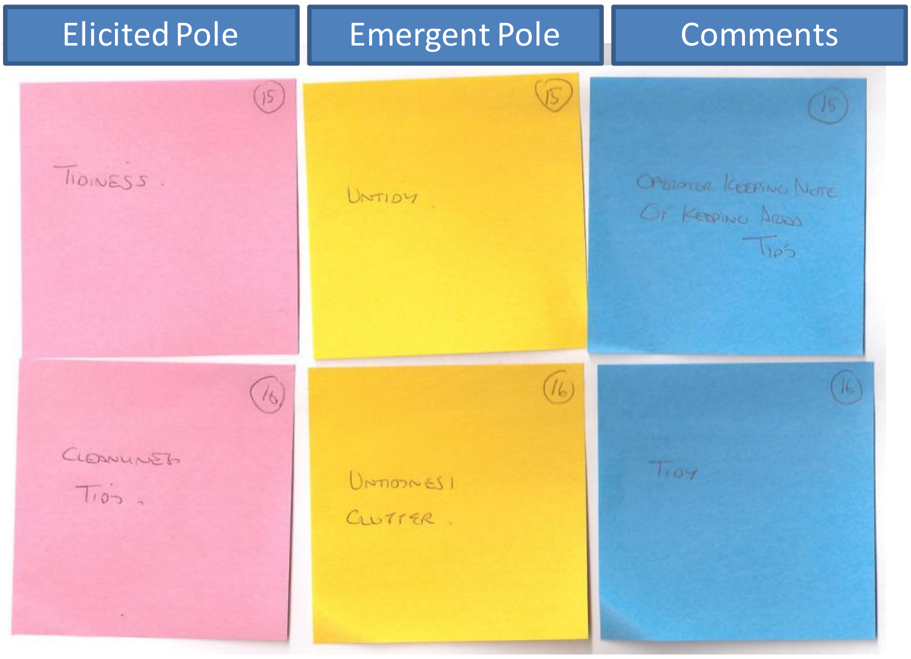


Figure I38 – Results of Photo-Elicitation – Triadic Sets 15 & 16 – Manager Nos. 4

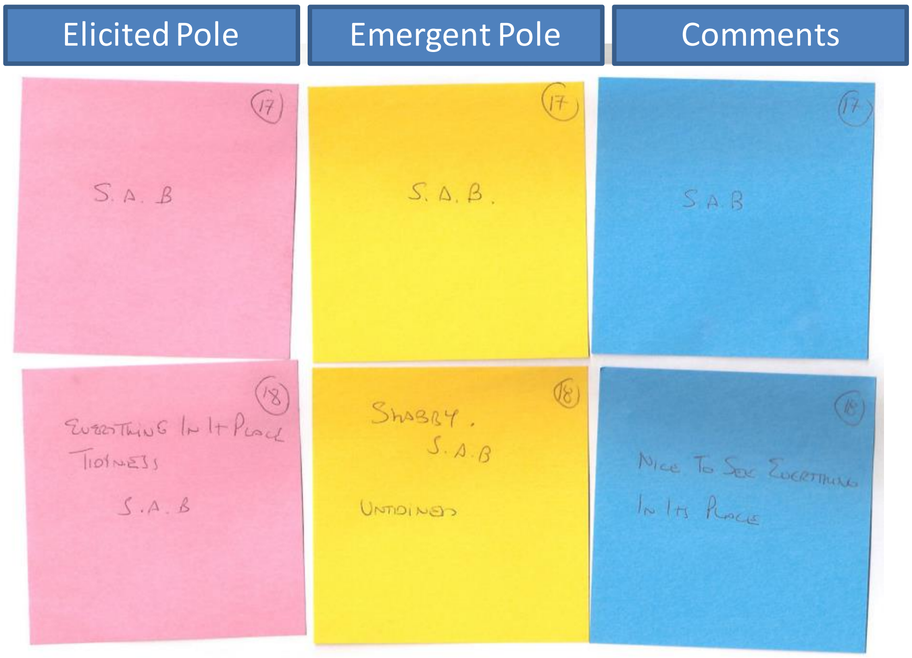


Figure I39 – Results of Photo-Elicitation – Triadic Sets 17 & 18 – Manager Nos. 4

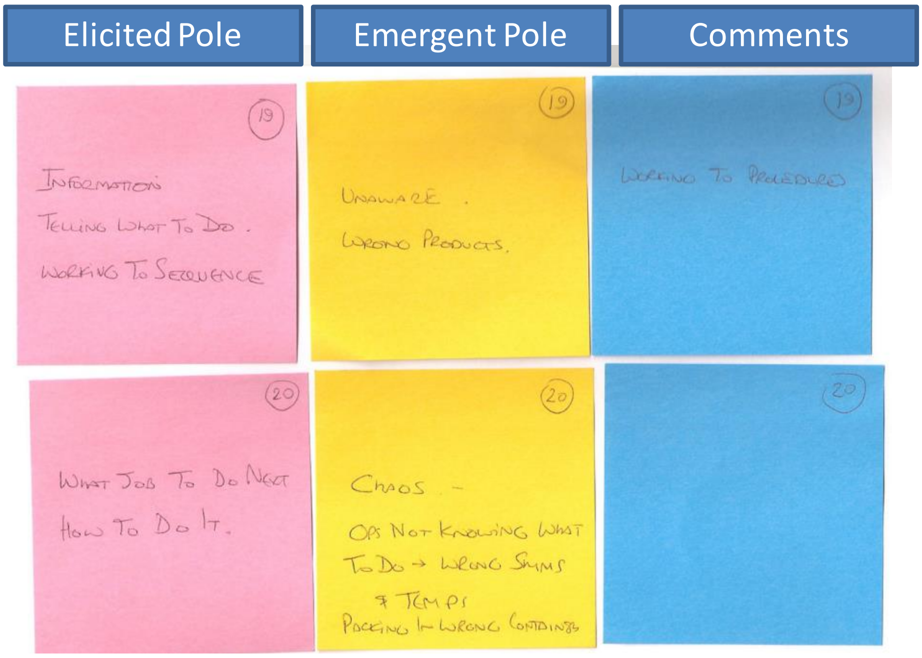


Figure I40 – Results of Photo-Elicitation – Triadic Sets 19 & 20 – Manager Nos. 4

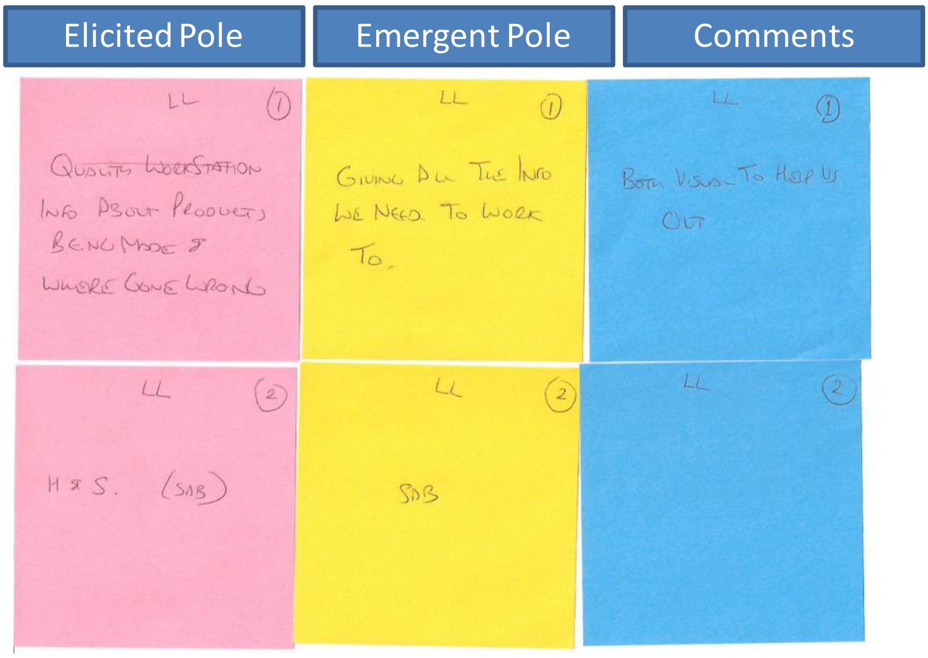


Figure I41 – Results of Photo-Elicitation – Triadic Sets 1 & 2 – Manager Nos. 5

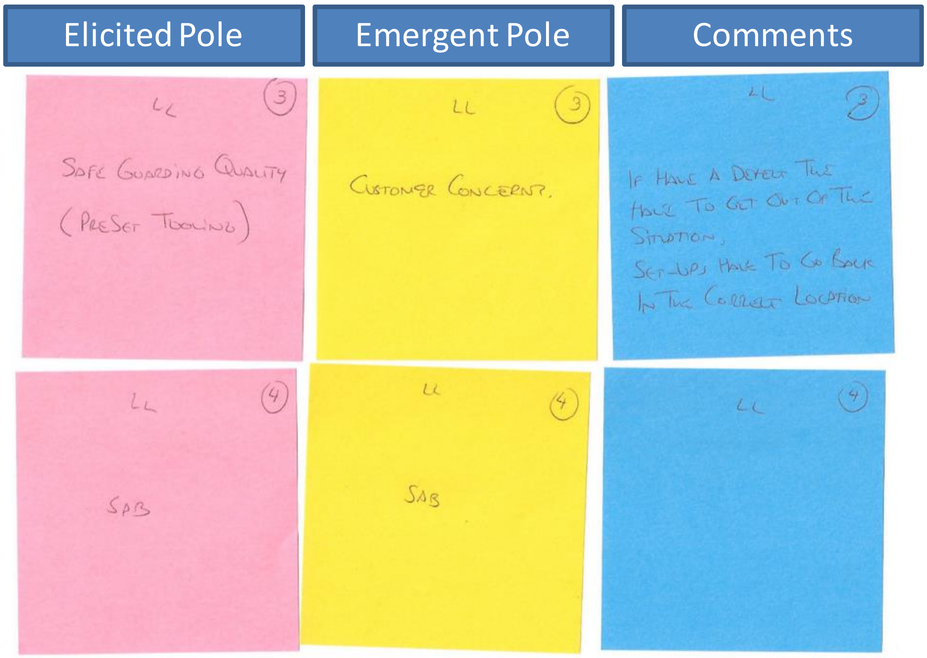


Figure I42 – Results of Photo-Elicitation – Triadic Sets 3 & 4 – Manager Nos. 5

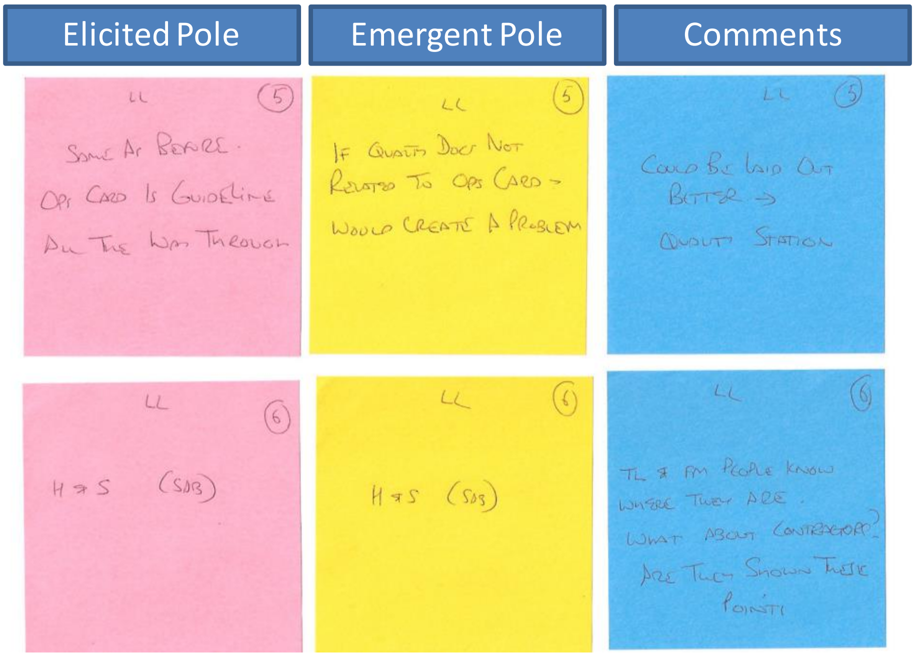


Figure I43 – Results of Photo-Elicitation – Triadic Sets 5 & 6 – Manager Nos. 5

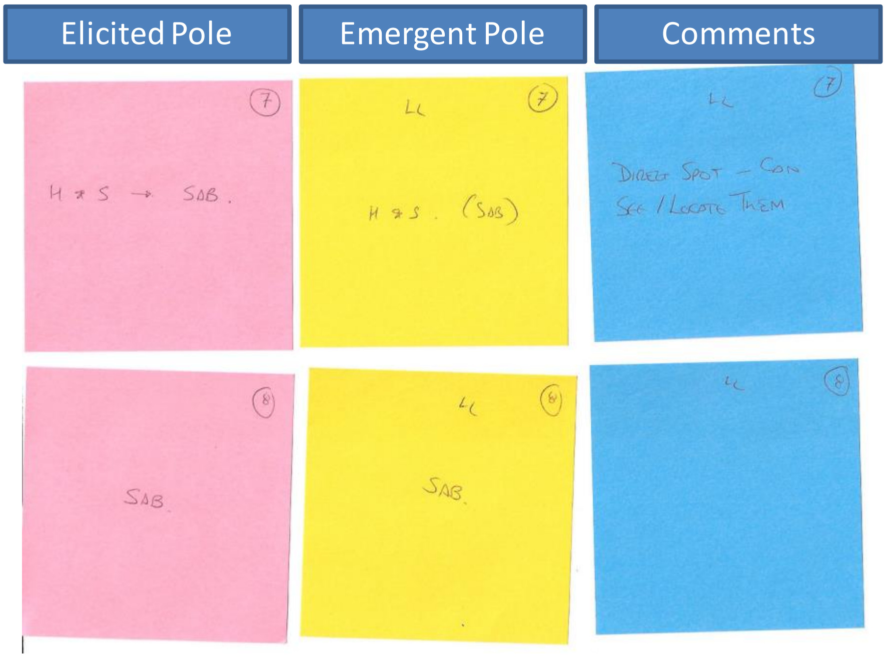


Figure I44 – Results of Photo-Elicitation – Triadic Sets 7 & 8 – Manager Nos. 5

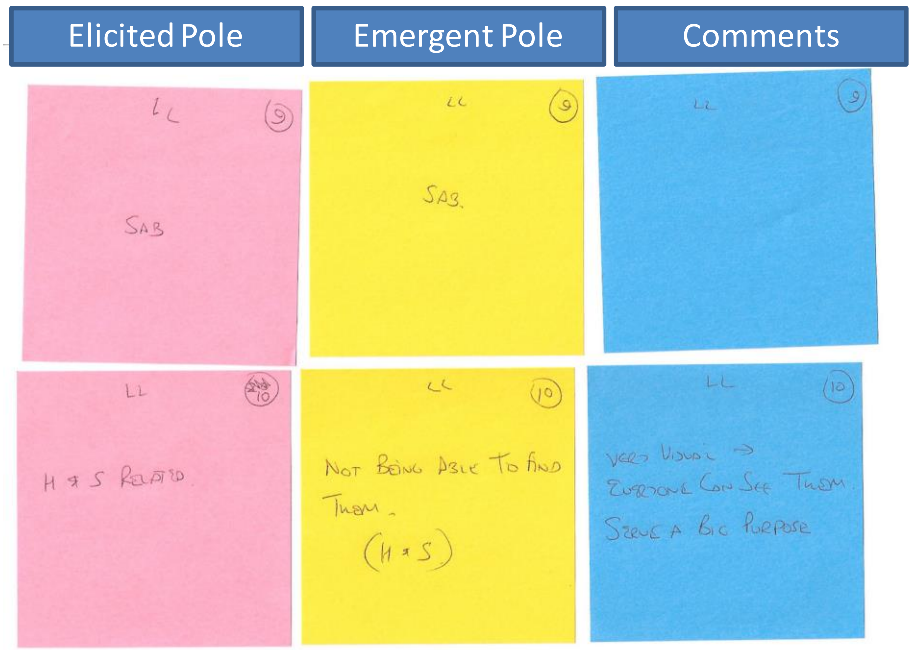


Figure I45 – Results of Photo-Elicitation – Triadic Sets 9 & 10 – Manager Nos. 5

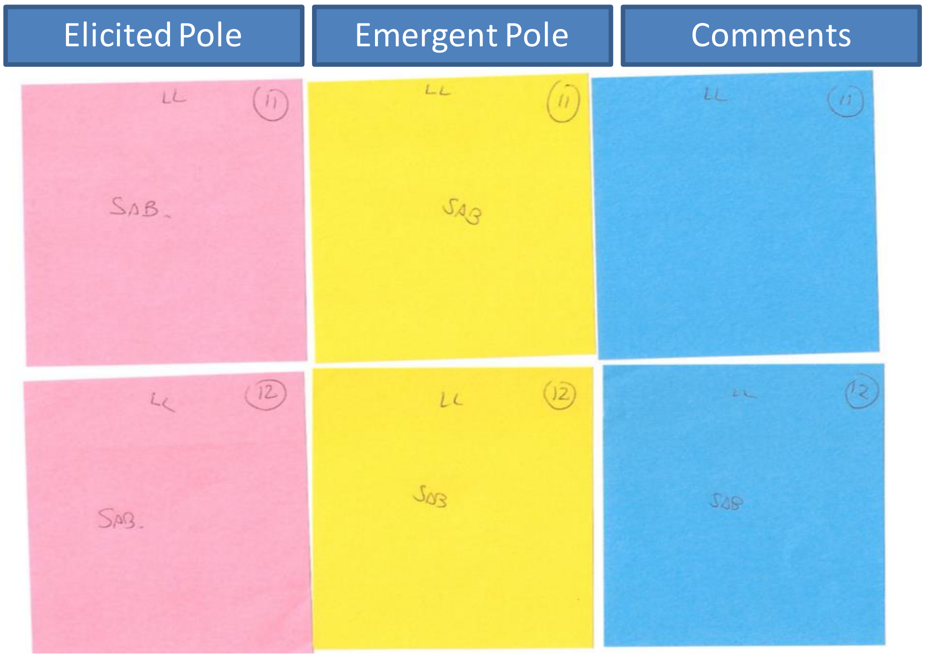


Figure I46 – Results of Photo-Elicitation – Triadic Sets 11 & 12 – Manager Nos. 5

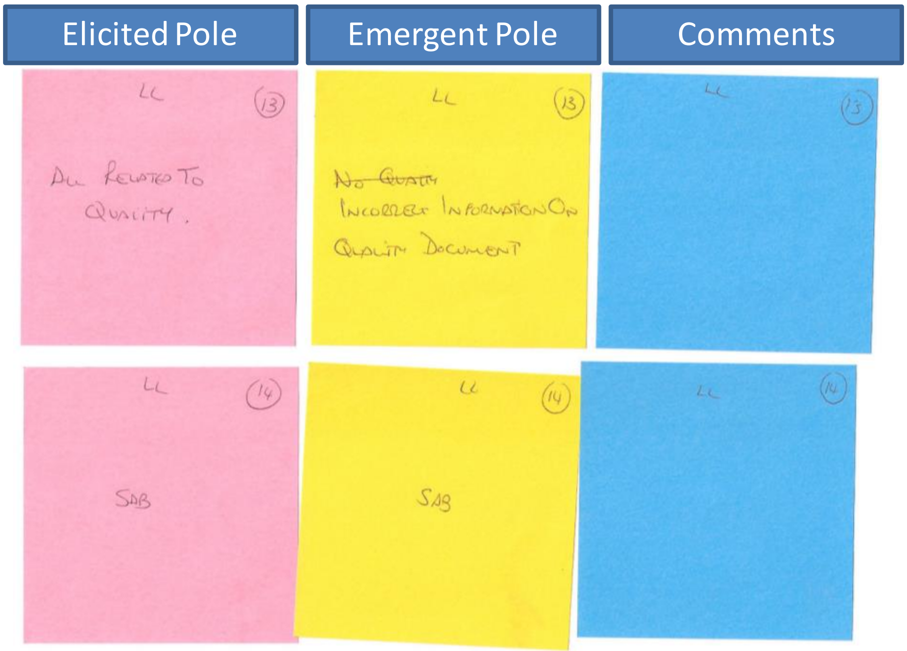


Figure I47 – Results of Photo-Elicitation – Triadic Sets 13 & 14 – Manager Nos. 5

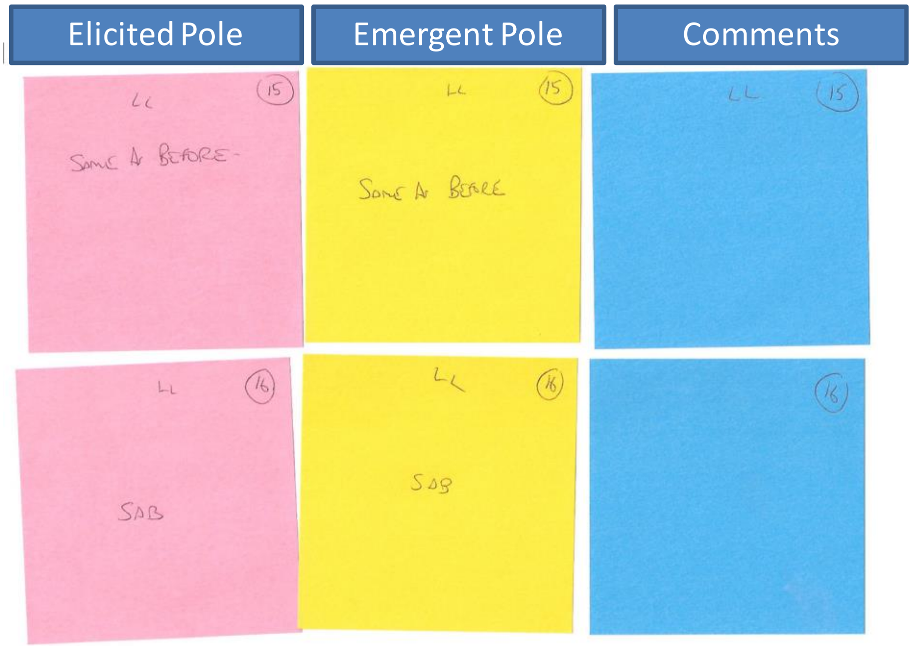


Figure I48 – Results of Photo-Elicitation – Triadic Sets 15 & 16 – Manager Nos. 5

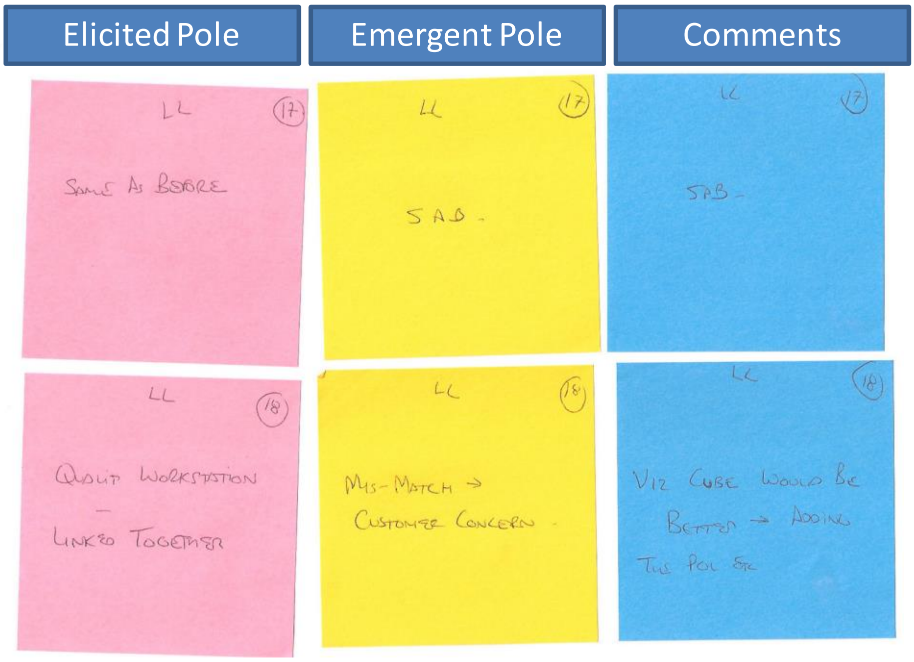


Figure I49 – Results of Photo-Elicitation – Triadic Sets 17 & 18 – Manager Nos. 5

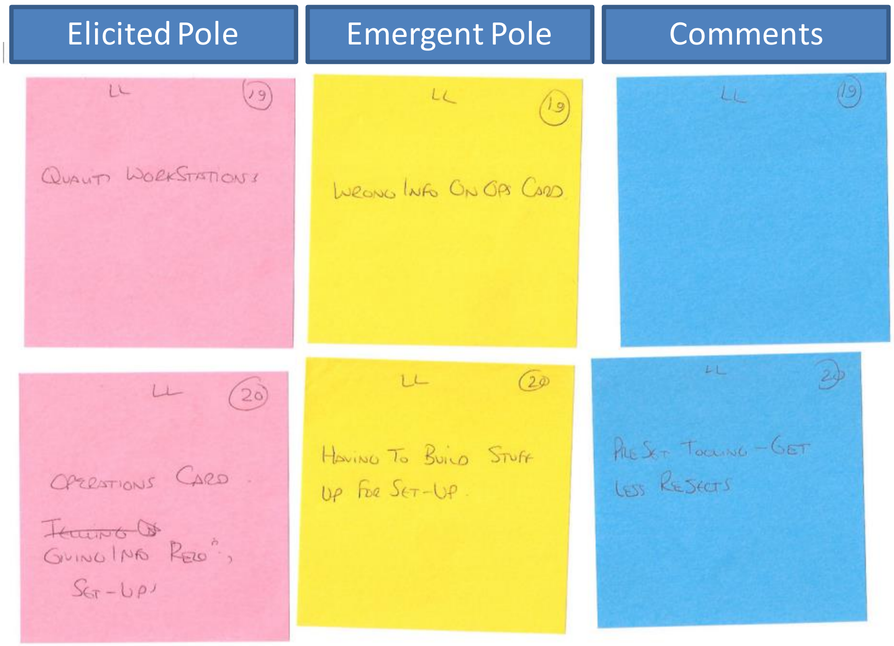


Figure I50 – Results of Photo-Elicitation – Triadic Sets 19 & 20 – Manager Nos. 5

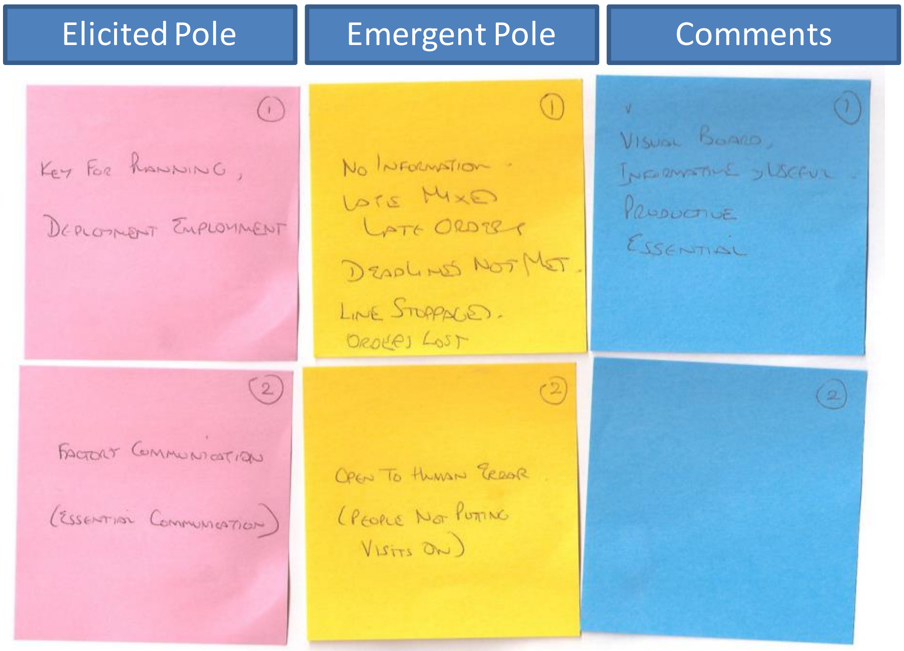


Figure I51 – Results of Photo-Elicitation – Triadic Sets 1 & 2 – Manager Nos. 6

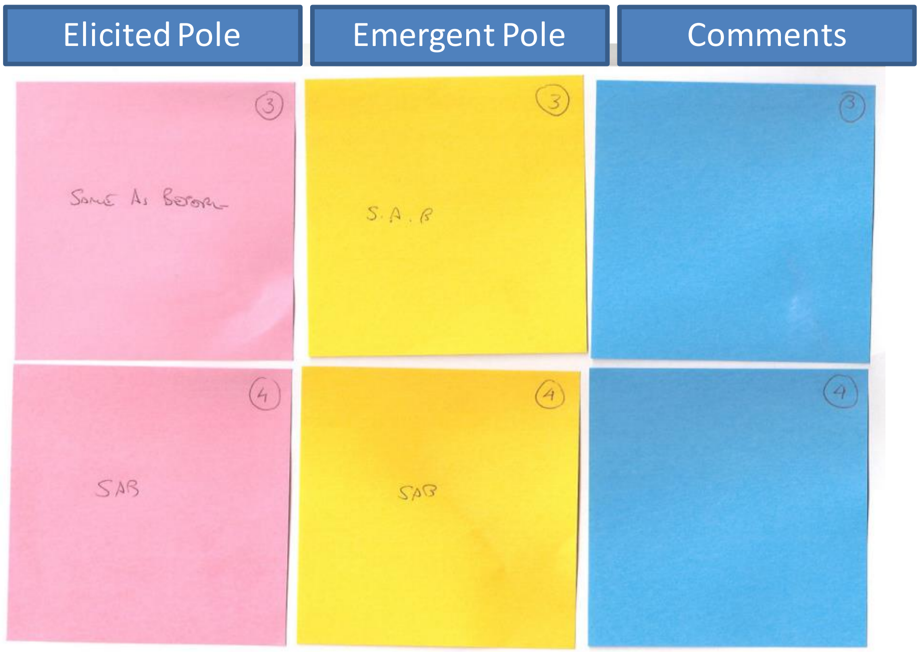


Figure I52 – Results of Photo-Elicitation – Triadic Sets 3 & 4 – Manager Nos. 6

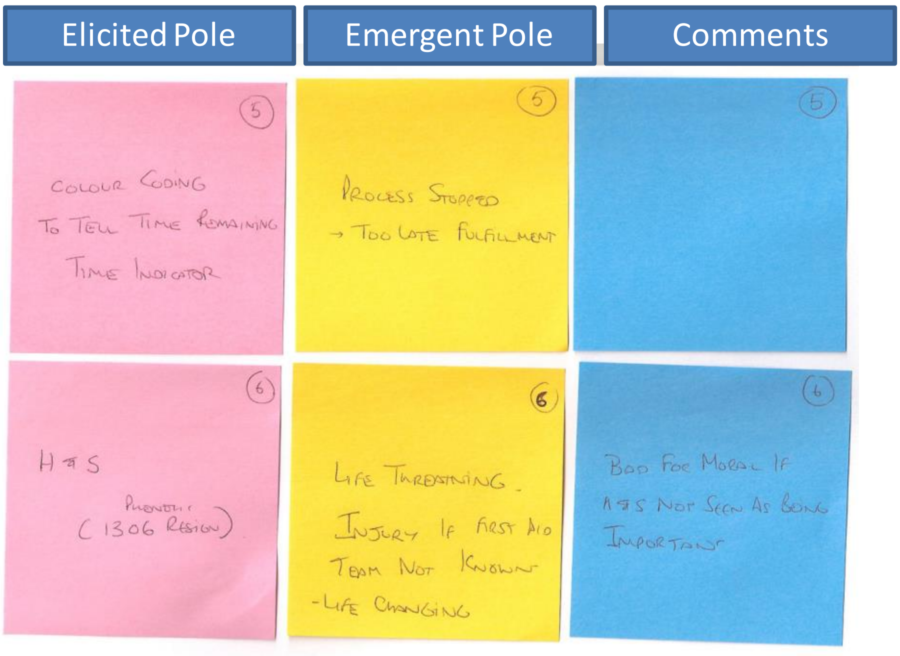


Figure I53 – Results of Photo-Elicitation – Triadic Sets 5 & 6 – Manager Nos. 6

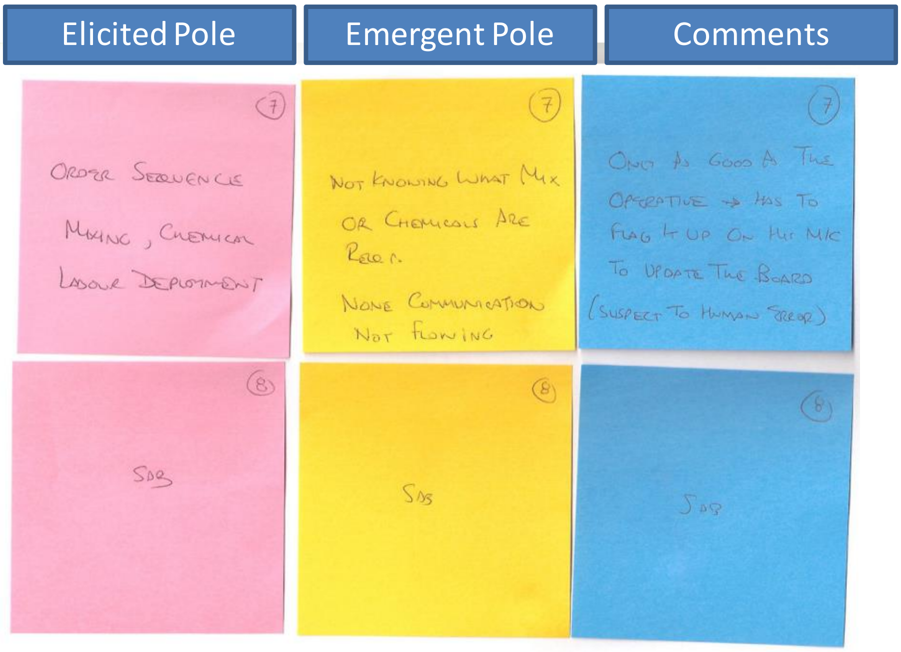


Figure I54 – Results of Photo-Elicitation – Triadic Sets 7 & 8 – Manager Nos. 6

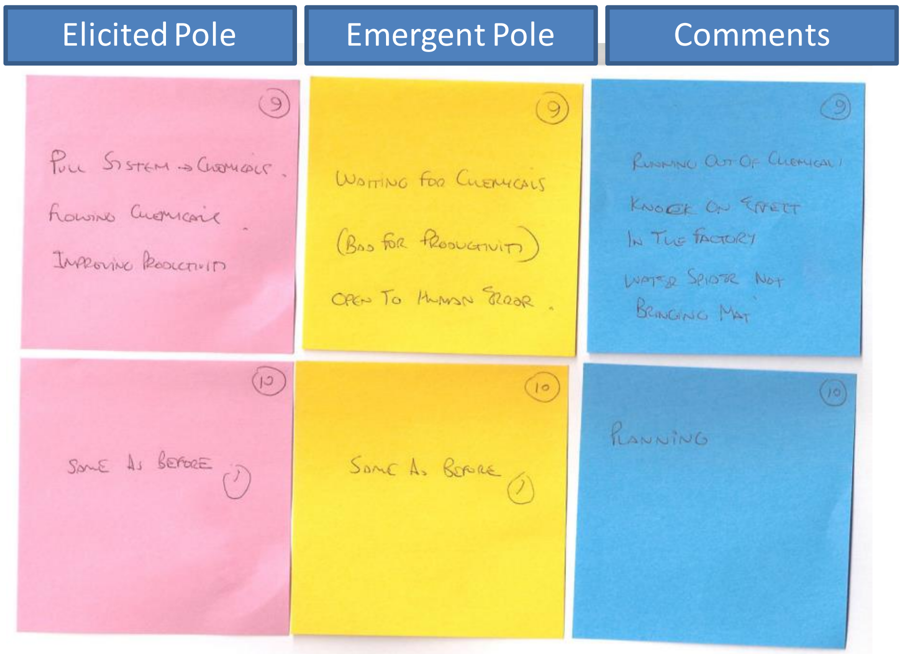


Figure I55 – Results of Photo-Elicitation – Triadic Sets 9 & 10 – Manager Nos. 6

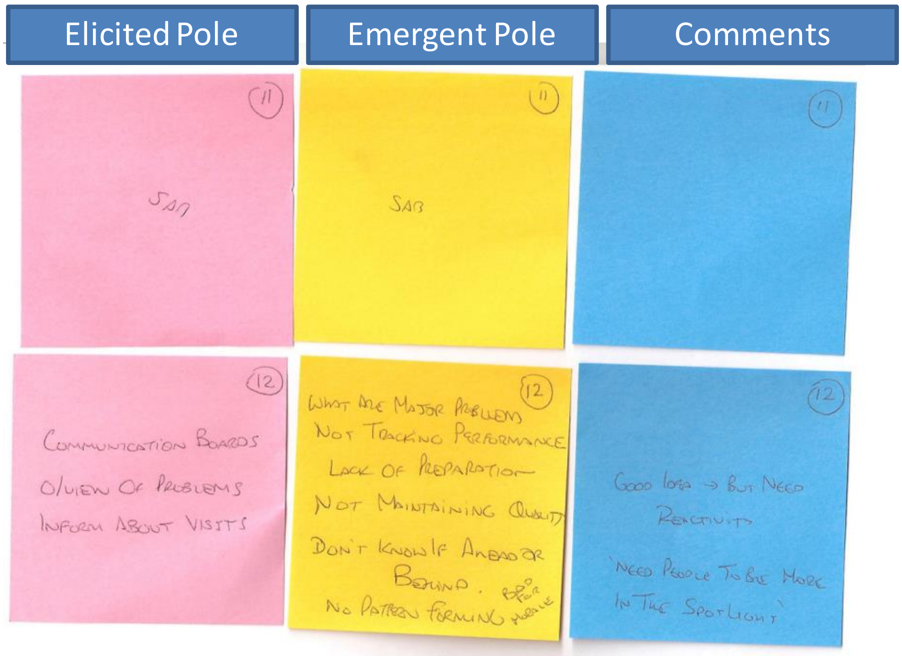


Figure I56 – Results of Photo-Elicitation – Triadic Sets 11 & 12 – Manager Nos. 6

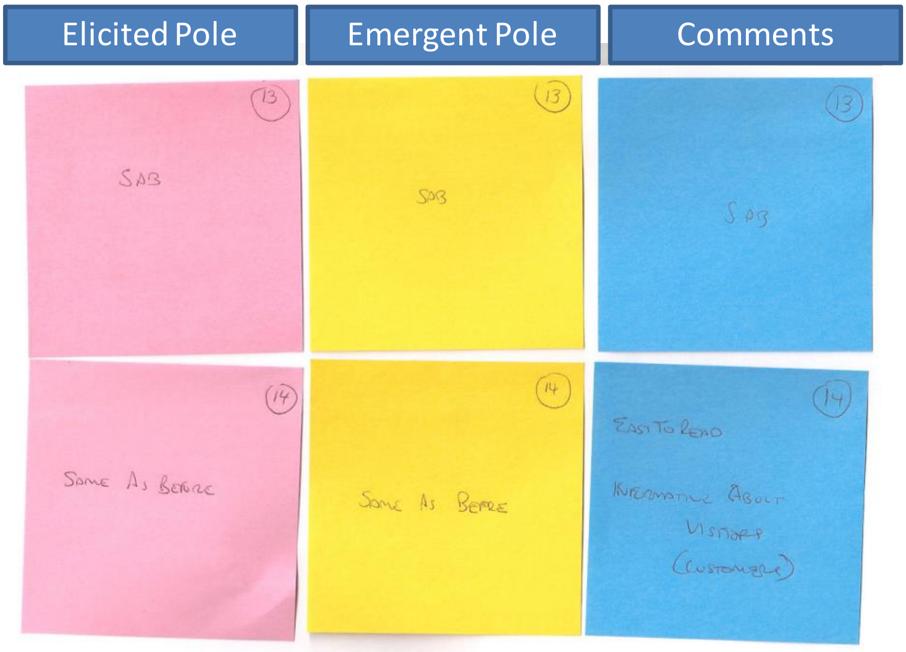


Figure I57 – Results of Photo-Elicitation – Triadic Sets 13 & 14 – Manager Nos. 6

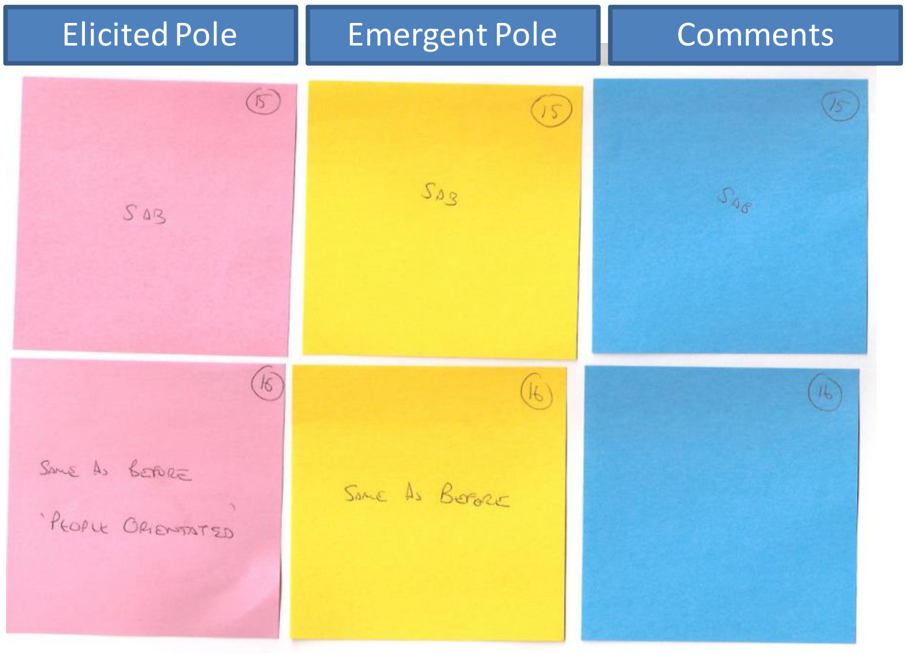


Figure I58 – Results of Photo-Elicitation – Triadic Sets 15 & 16 – Manager Nos. 6

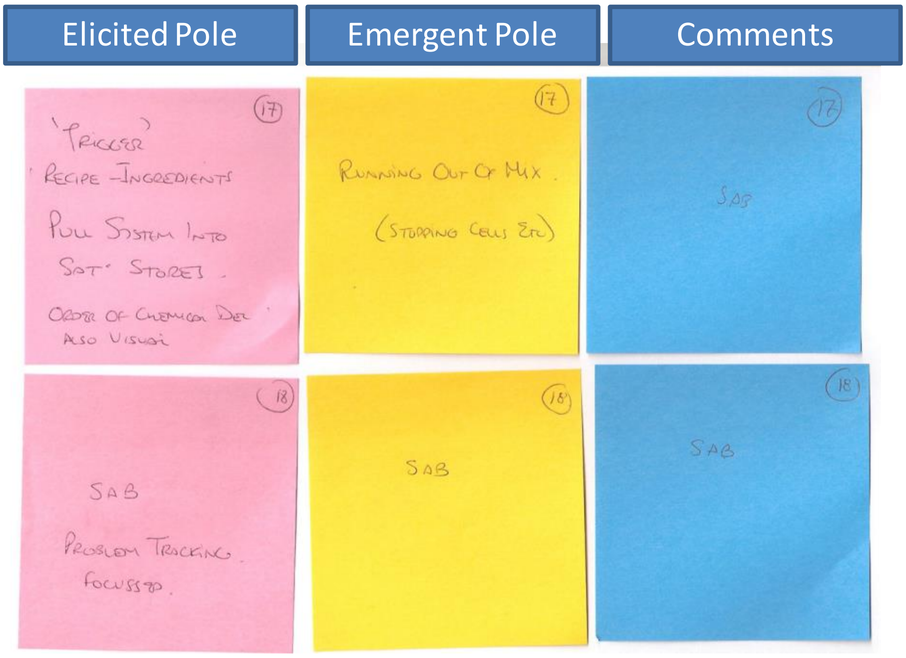


Figure I59 – Results of Photo-Elicitation – Triadic Sets 17 & 18 – Manager Nos. 6

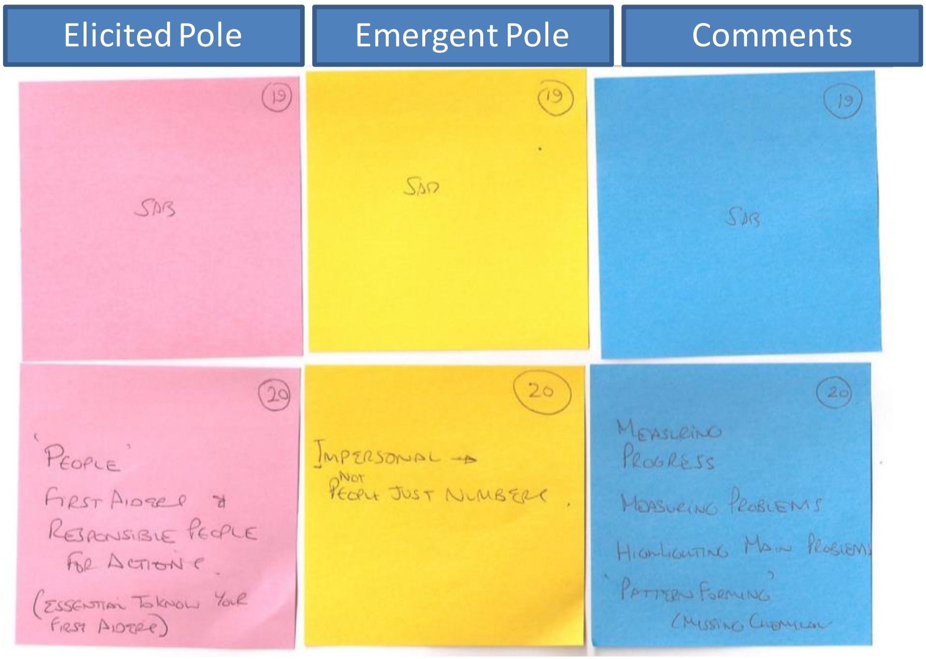


Figure I60 – Results of Photo-Elicitation – Triadic Sets 19 & 20 – Manager Nos. 6

8.10 Appendix J – Results from ECRS Activity with the Managers

The 20 bi-polar constructs shown above for each of the managers (**Appendix I**) have been simplified by the managers using the ECRS methodology (eliminate, combine, rearrange, simplify). Shown below, for each of the six managers, is a collage of each of the themes along with the constructs that have led to that theme emerging. The details of the individual post-it notes are not clearly visible, however the purpose of providing this image is only to visualise the usage of ECRS.

Figure J1 – Collage – Result of ECRS Activity - Themes for Manager 1

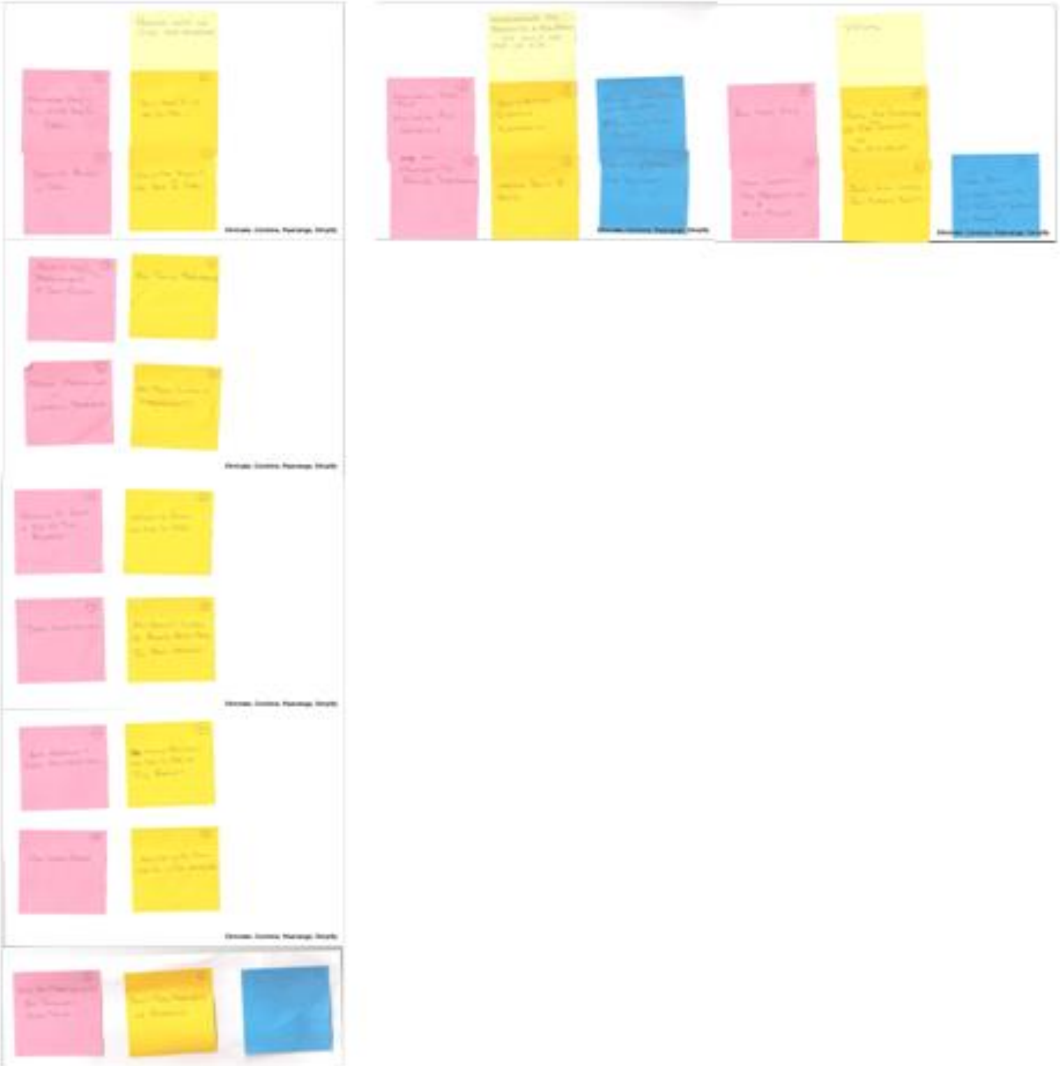


Figure J2 - Collage – Result of ECRS Activity - Themes for Manager 2

Figure J3 - Collage – Result of ECRS Activity - Themes for Manager 3

Figure J4 - Collage – Result of ECRS Activity - Themes for Manager 4

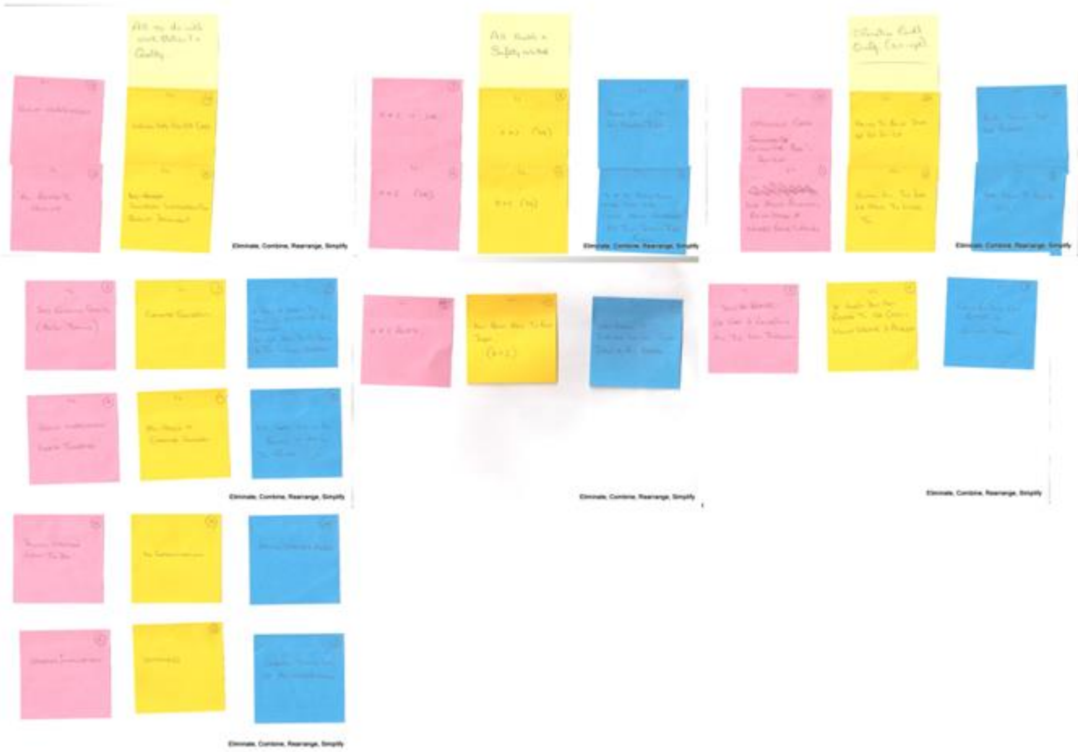


Figure J5 - Collage – Result of ECR S Activity - Themes for Manager 5

Figure J6 - Collage – Result of ECRS Activity - Themes for Manager 6

8.11 Appendix K – Consolidated Themes & Pole Questions

The results of the ECRS activity with the six managers were tabulated as shown below in figures L1 to L6. I compared the themes identified by the managers with other to identify those that were repeated or similar to others. In this way I consolidated the themes from 36 to 10. My notes of this comparison are recorded in the 'Researcher Consolidation' column. The following six tables show the wording of the themes as recorded by the managers and how these were compared.

Having consolidated the themes to ten core themes I identified a phrase referred to as common stimulus. This was to identify a keyword, or bullet point, which would be used as part of the questionnaire to ensure that respondents could follow the impetus of each of the constructs (Dillman 2007).

		ECRS			Questionnaire Design		
Manager		Theme	Researcher Consolidation	Unique Construct	Common Stimulus	Left Hand Pole	Right Hand Pole
1	1	Awareness in Area	Similar to theme 7 from Manager 6				
	2	Visual & Verbal	Similar to theme 7 from Manager 6				
	3	Injury Awareness	Similar to theme 7 from Manager 6				
	4	Quality	Similar to theme 7 from Manager 6				
	5	Visual & Verbal Communication	Similar to theme 1 from Manager 2				
	6	Be Alert in Area	Similar to theme 7 from Manager 6				
	7	Stop - Do Not Enter	Similar to theme 7 from Manager 6				
	8	Follow Cell Procedure	Similar to theme 3 from Manager 5				
	9	Measure the Product	Similar to theme 2 from Manager 2				
	10	Traffic Movement	Perhaps Unique - but comments seem to relate more to theme 8 above	12			

Figure K1 – Consolidated Themes – Stimulus and Pole Questions Design – Manager 1

		ECRS			Questionnaire Design		
Manager		**Theme**	**Researcher Consolidation**	**Unique Construct**	**Common Stimulus**	**Left Hand Pole**	**Right Hand Pole**
2	1	Process not in Control - No Evidence	Focussed on Process Control	**7**	Process Control	**Strong focus on Process Control**	**Weak focus on Process Control**
	2	Measurements to Products and Equipment - To show we are in Control	Focussed on Measurement and Recording	**8**	Measurement & Recording	**Strong focus on Measurement & Recording**	**Weak focus on Measurement & Recording**
	3	Visual	Related to theme 7				

Figure K2 – Consolidated Themes – Stimulus and Pole Questions Design – Manager 2

		ECRS			Questionnaire Design		
Manager		**Theme**	**Researcher Consolidation**	**Unique Construct**	**Common Stimulus**	**Left Hand Pole**	**Right Hand Pole**
3	1	Improvements or lack of	Focussed on Making Improvements	**9**	Improvements	**Strong focus on Making Improvements**	**Weak focus on Making Improvements**
	2	Production Tracking / Output	Focussed on Production Output Tracking	**10**	Production Ouput	**Strong focus on Production Output Tracking**	**Weak focus on Production Output Tracking**
	3	Production Scheduling	Similar to theme 1 from Manager 6				
	4	Kanban - Over Production	Similar to theme 1 from Manager 6				

Figure K3 – Consolidated Themes – Stimulus and Pole Questions Design – Manager 3

		ECRS			Questionnaire Design		
Manager		Theme	Researcher Consolidation	Unique Construct	Common Stimulus	Left Hand Pole	Right Hand Pole
4	1	Communication Throughout	Focussed on Infomration / feedback for operators	1	Communication	Strong focus on Information / Feedback for Operators	Weak focus on Information / Feedback for Operators
	2	Dusty & Dirty	Focussed on Cleanliness and Tidiness	2	5S	Strong focus on Cleanliness & Tidiness	Weak focus on Cleanliness & Tidiness
	3	Informing	Related to theme 1 above				
	4	Operator Listening - Working to Procedures	Related to theme 1 above				
	5	Working to Procedure	Related to theme 1 above				

Figure K4 – Consolidated Themes – Stimulus and Pole Questions Design – Manager 4

		ECRS			Questionnaire Design		
Manager		Theme	Researcher Consolidation	Unique Construct	Common Stimulus	Left Hand Pole	Right Hand Pole
5	1	Health & Safety	Related to theme 7 from Manager 6				
	2	Workstations and Quality	Focussed on Quality	5	Quality	Strong focus on Quality	Weak focus on Quality
	3	Operator Cards - Quality Set-ups	Focussed on set-up information	6	Set-Up Information	Strong focus on Set-Up Information	Weak focus on Set-Up Information

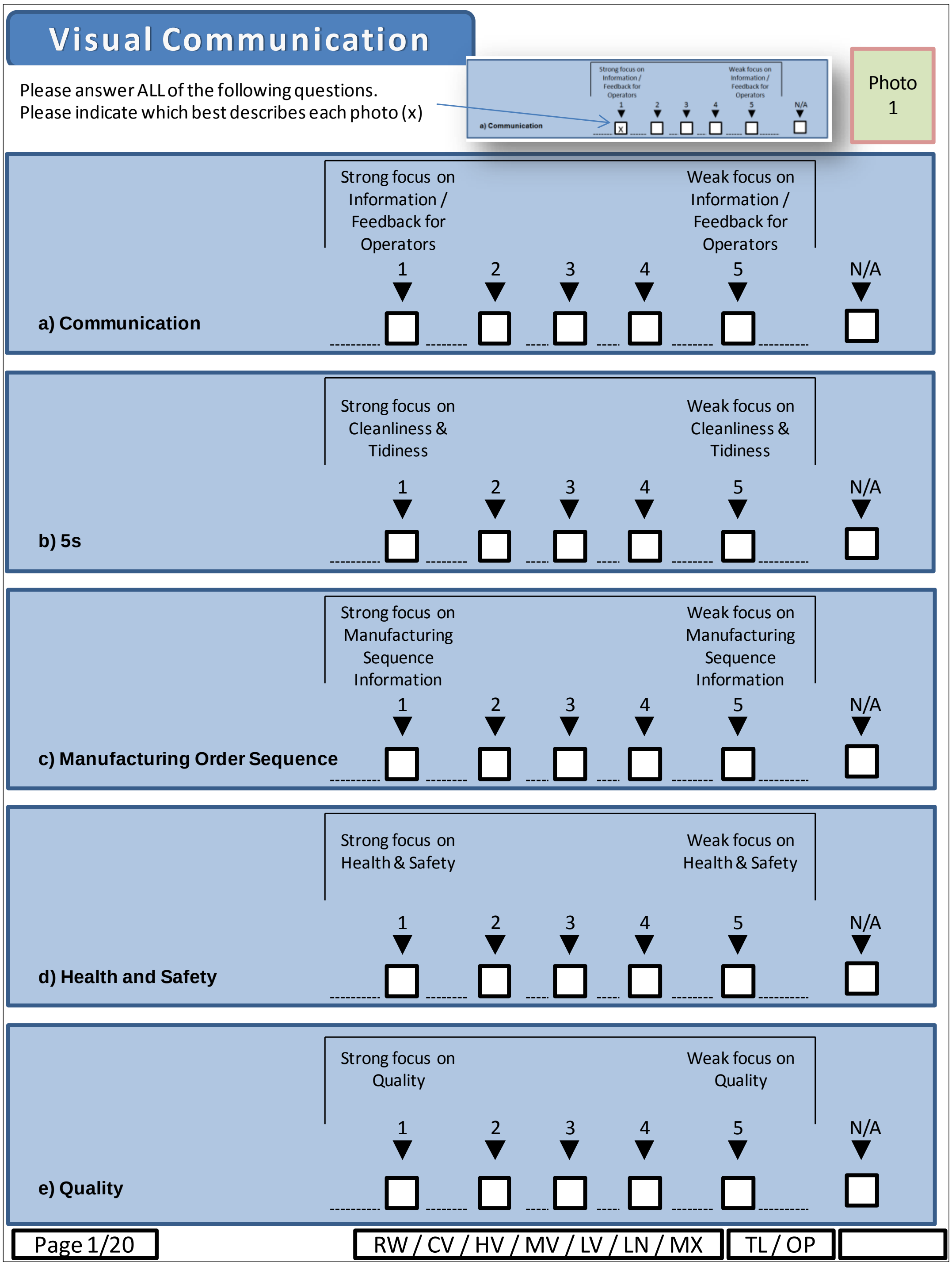
Figure K5 – Consolidated Themes – Stimulus and Pole Questions Design – Manager 5

		ECRS			Questionnaire Design		
Manager		**Theme**	**Researcher Consolidation**	**Unique Construct**	**Common Stimulus**	**Left Hand Pole**	**Right Hand Pole**
6	**1**	Mix Order and Sequence of Mixing	Focussed on Manufacturing Sequence Information	**3**	Manufacturing Order Sequence	**Strong focus on Manufacturing Sequence Information**	**Weak focus on Manufacturing Sequence Information**
	2	Chemical Ordering	Related to above				
	3	Waiting for Chemicals	Related to above				
	4	Mixes Times Needed	Related to above				
	5	Cells Stopped	Related to above				
	6	Factory Communication	Related to theme 1 from Manager 4				
	7	First Aiders / People	Focussed on Health and Safety	**4**	Health & Safety	**Strong focus on Health & Safety**	**Weak focus on Health & Safety**
	8	Communication of Performance	Related to theme 1 from Manager 4				
	9	Problem Tracking	Unique but prioritised low	**11**			
	10	Visual	Relarted to above				
	11	H&S - First Aiders	Related to above				

Figure K6 – Consolidated Themes – Stimulus and Pole Questions Design – Manager 6

8.12 Appendix L – Questionnaire Design (Format)

Shown below (next page) is the design of the questionnaire sheet. The questionnaire was printed on A4 double sided.



Visual Communication

Please answer ALL of the following questions.
Please indicate which best describes each photo (x)

Photo 1

	Strong focus on Information / Feedback for Operators				Weak focus on Information / Feedback for Operators	
	1	2	3	4	5	N/A
a) Communication	☐	☐	☐	☐	☐	☐

	Strong focus on Cleanliness & Tidiness				Weak focus on Cleanliness & Tidiness	
	1	2	3	4	5	N/A
b) 5s	☐	☐	☐	☐	☐	☐

	Strong focus on Manufacturing Sequence Information				Weak focus on Manufacturing Sequence Information	
	1	2	3	4	5	N/A
c) Manufacturing Order Sequence	☐	☐	☐	☐	☐	☐

	Strong focus on Health & Safety				Weak focus on Health & Safety	
	1	2	3	4	5	N/A
d) Health and Safety	☐	☐	☐	☐	☐	☐

	Strong focus on Quality				Weak focus on Quality	
	1	2	3	4	5	N/A
e) Quality	☐	☐	☐	☐	☐	☐

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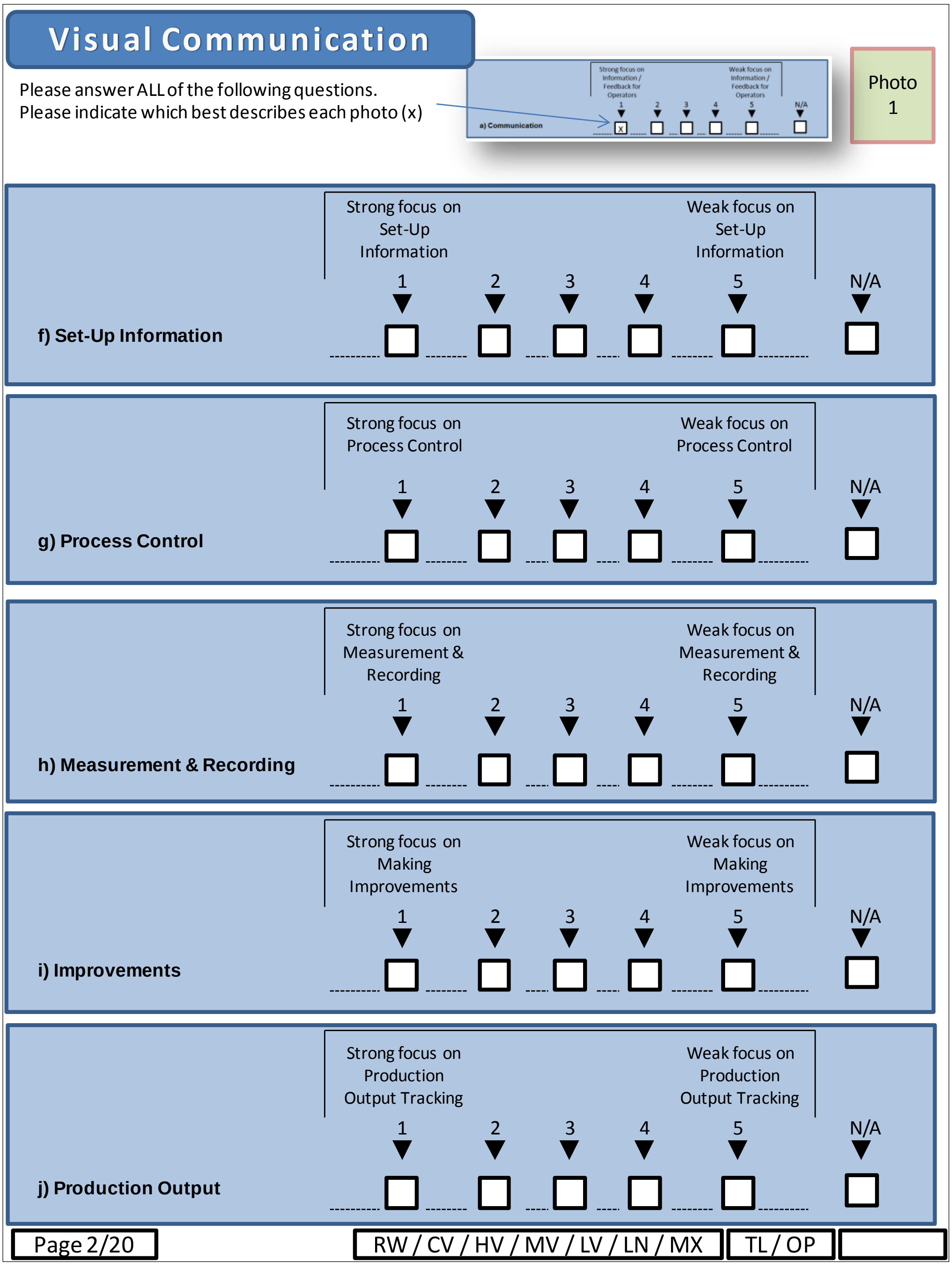
Figure L1 – Questionnaire Design – Side 1



Visual Communication

Please answer ALL of the following questions.
Please indicate which best describes each photo (x)

Photo 1

	Strong focus on Set-Up Information 1	2	3	4	Weak focus on Set-Up Information 5	N/A
f) Set-Up Information	☐	☐	☐	☐	☐	☐

	Strong focus on Process Control 1	2	3	4	Weak focus on Process Control 5	N/A
g) Process Control	☐	☐	☐	☐	☐	☐

	Strong focus on Measurement & Recording 1	2	3	4	Weak focus on Measurement & Recording 5	N/A
h) Measurement & Recording	☐	☐	☐	☐	☐	☐

	Strong focus on Making Improvements 1	2	3	4	Weak focus on Making Improvements 5	N/A
i) Improvements	☐	☐	☐	☐	☐	☐

	Strong focus on Production Output Tracking 1	2	3	4	Weak focus on Production Output Tracking 5	N/A
j) Production Output	☐	☐	☐	☐	☐	☐

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Figure L2 – Questionnaire Design – Side 2

8.13 Appendix M – Ten Photographs Rated using the Questionnaire

The following 10 photographs were selected from the pool of unused photographs from the participant-led-photography activity. These were the elements that we used for the rating using the questionnaire.

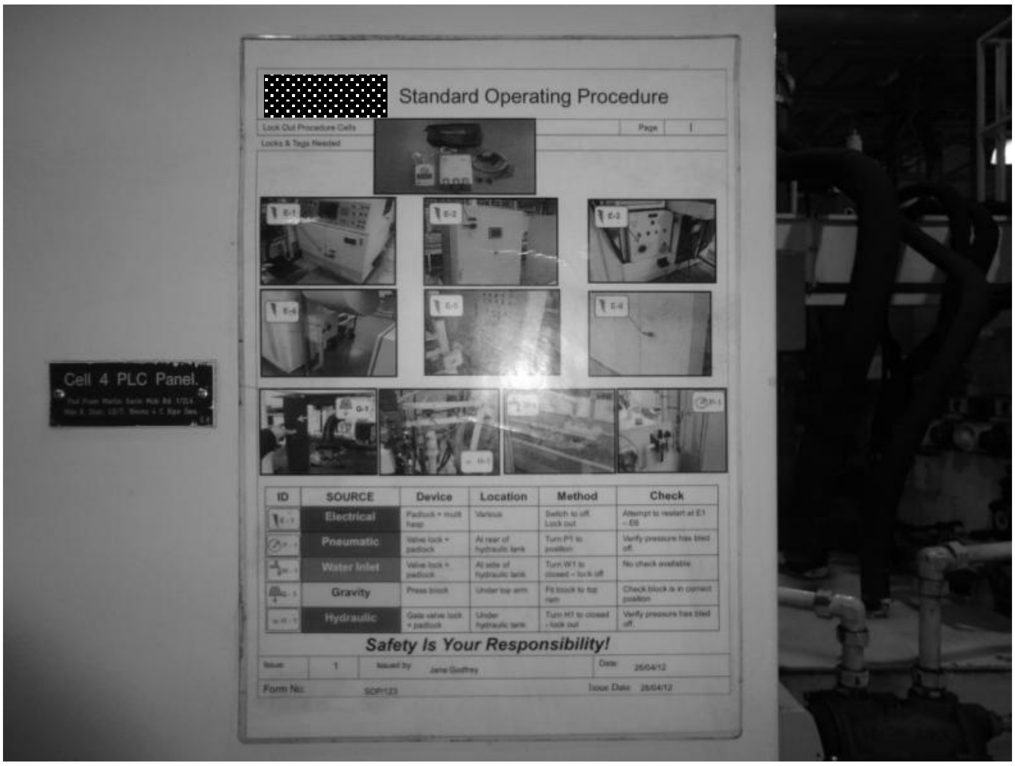


Figure M1 - Photograph Nos. 1 (Photo taken by Manager Number 3)

Figure M2 - Photograph Nos. 2 (Photo taken by Manager Number 5)

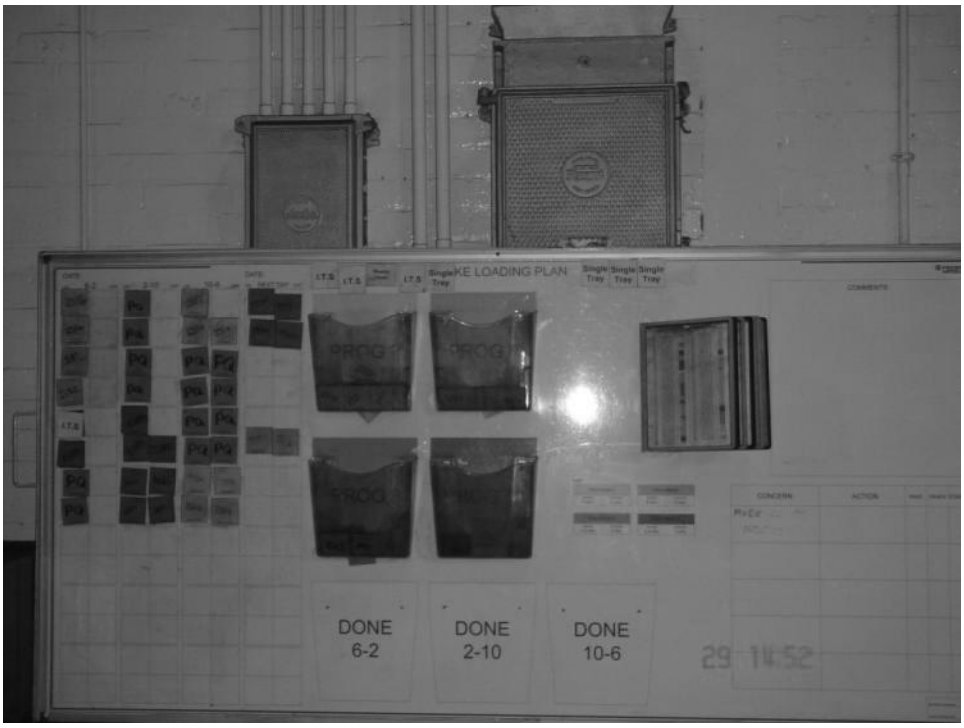


Figure M3 - Photograph Nos. 3 (Photo taken by Manager Number 5)

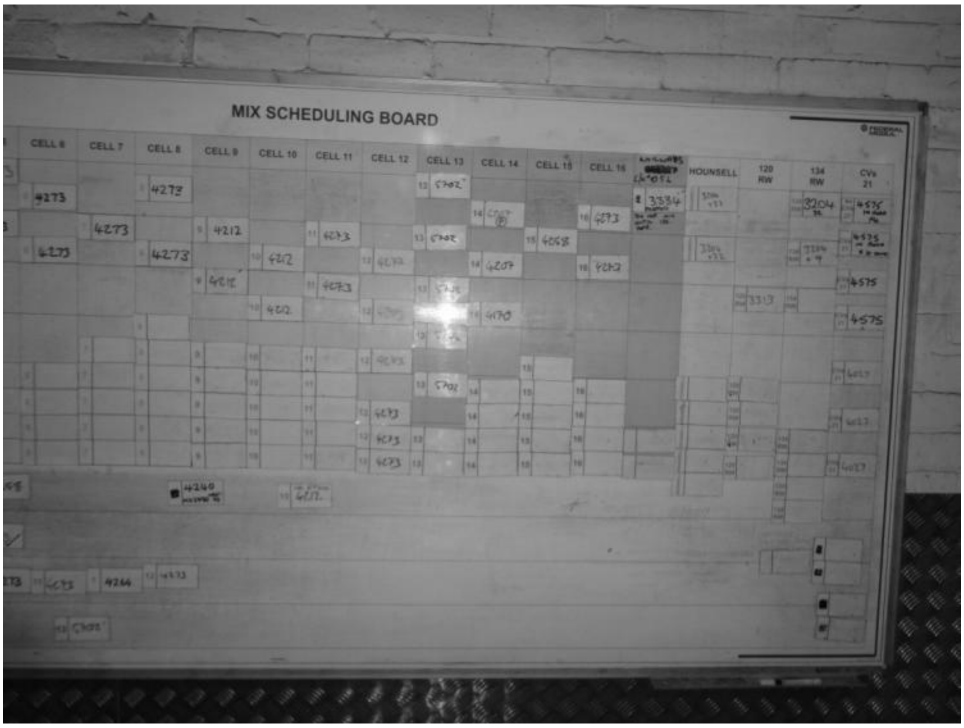


Figure M4 - Photograph Nos. 4 (Photo taken by Manager Number 6)

Figure M5 - Photograph Nos. 5 (Photo taken by Manager Number 6)

Figure M6 - Photograph Nos. 6 (Photo taken by Manager Number 1)

Figure M7 - Photograph Nos. 7 (Photo taken by Manager Number 2)

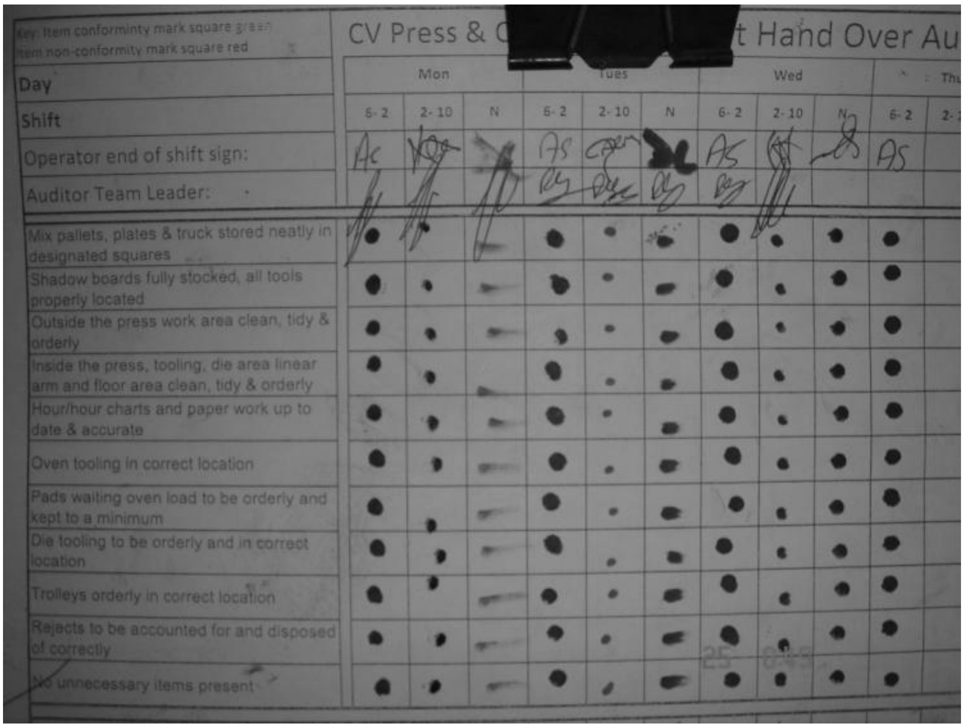


Figure M8 - Photograph Nos. 8 (Photo taken by Manager Number 2)

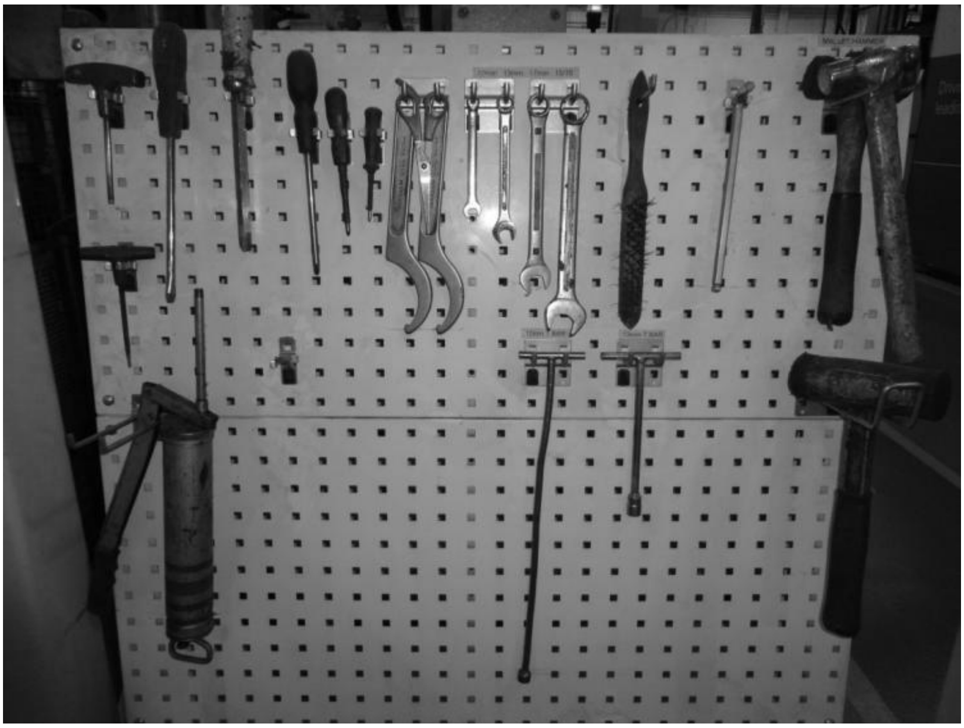


Figure M9 - Photograph Nos. 9 (Photo taken by Manager Number 4)

Figure M10 - Photograph Nos. 10 (Photo taken by Manager Number 4)

8.14 Appendix N – Summary of Results and Fisher Exact Test

A way of validating exact match data is to use **Fisher's exact test** (Ronald Fisher). This test is used to determine if the associations between variables, in this case the response from the managers compared to the operators, can be considered as being due to random chance. In this research this test was done by keeping the response of the managers fixed but by seeing how many exact matches could possibly be achieved if the responses from the operators were reordered according to every possible permutation. This permuting of operator responses enabled a comparison to be made of all possible exact matches

Shown below are the full table of the actual survey results alongside the permutation tests results from the Fisher Analysis. This shows that the exact match responses obtained from the survey are overall unlikely to be due to chance alone. Although for some photographs the differences between observed results and possible results based on the permutations are inconclusive, these results should in my opinion be taken as a whole, considering only matches of ratings one and two were considered.

Photograph 1

Observed Results / Random Permutations of Operators Data

Value Stream 1

Rating	Nos of Matches	Σ Matches	% Matches
#1	2	6	10%
#2	4		
#3	1		
#4			
#5	1		
#N/A	6		
Mis-match	46		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%					12	16	7172	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0001

Value Stream 2

Rating	Nos of Matches	Σ Matches	% Matches
#1	5	5	8%
#2			
#3			
#4			
#5			
#N/A	17		
Mis-match	38		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.3%			10			10	7180	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.009

Value Stream 3

Rating	Nos of Matches	Σ Matches	% Matches
#1	11	11	18%
#2			
#3	4		
#4			
#5			
#N/A	3		
Mis-match	42		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
8.7%	10				152	464	6574	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.137

Value Stream 4

Rating	Nos of Matches	Σ Matches	% Matches
#1	15	16	27%
#2	1		
#3	2		
#4			
#5	2		
#N/A			
Mis-match	40		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.7%	10		10	8	22		7150	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0005

Value Stream 5

Rating	Nos of Matches	Σ Matches	% Matches
#1		6	10%
#2	6		
#3			
#4	1		
#5	4		
#N/A	3		
Mis-match	46		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%			10		4	16	7170	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.006

Value Stream 6

Rating	Nos of Matches	Σ Matches	% Matches
#1	9	10	17%
#2	1		
#3	2		
#4			
#5			
#N/A			
Mis-match	48		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%	10			10	4	6	7170	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.004

Figure N1- Photograph 1 - Observed Results versus Fisher Exact Match Test

Photograph 2

Observed Results / Random Permutations of Operators Data

	Rating	Nos of Matches	Σ Matches	% Matches		% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 1	#1	12	19	32%	⇔	11.0%			20	148	468	154	6410	Freq. of Matches
	#2	7					6	5	4	3	2	1	0	Rating
	#3	1												
	#4				p Value -	0.167								
	#5													
	#N/A													
	Mis-match	40												
Value Stream 2	#1	8	9	15%	⇔	10.4%				154	448	148	6450	Freq. of Matches
	#2	1					6	5	4	3	2	1	0	Rating
	#3													
	#4				p Value -	0.784								
	#5													
	#N/A	7												
	Mis-match	44												
Value Stream 3	#1	10	11	18%	⇔	10.4%				736	6	8	6450	Freq. of Matches
	#2	1					6	5	4	3	2	1	0	Rating
	#3	2												
	#4				p Value -	0.879								
	#5													
	#N/A	6												
	Mis-match	41												
Value Stream 4	#1	15	16	27%	⇔	10.8%	10			154	442	170	6424	Freq. of Matches
	#2	1					6	5	4	3	2	1	0	Rating
	#3	1												
	#4				p Value -	0.307								
	#5	1												
	#N/A	3												
	Mis-match	39												
Value Stream 5	#1	18	19	32%	⇔	10.6%	730		10		14	6	6440	Freq. of Matches
	#2	1					6	5	4	3	2	1	0	Rating
	#3													
	#4				p Value -	0.890								
	#5	1												
	#N/A	2												
	Mis-match	38												
Value Stream 6	#1	10	18	30%	⇔	10.8%	10	144	0	442	16	164	6424	Freq. of Matches
	#2	8					6	5	4	3	2	1	0	Rating
	#3	1												
	#4				p Value -	0.556								
	#5	2												
	#N/A													
	Mis-match	39												

Figure N2- Photograph 2 - Observed Results versus Fisher Exact Match Test

Photograph 3

Observed Results

Random Permutations of Operators Data

Value Stream 1

Rating	Nos of Matches	∑ Matches	% Matches
#1		0	0%
#2			
#3			
#4	1		
#5			
#N/A	1		
Mis-match	58		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.0%	0	0	0	0	0	0	7200	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0

Value Stream 2

Rating	Nos of Matches	∑ Matches	% Matches
#1	1	1	2%
#2			
#3			
#4	1		
#5	3		
#N/A	2		
Mis-match	53		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.1%	0	0	0	0	0	6	7194	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0005

Value Stream 3

Rating	Nos of Matches	∑ Matches	% Matches
#1		3	5%
#2	3		
#3	1		
#4	1		
#5	2		
#N/A	12		
Mis-match	41		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.3%						22	7178	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.001

Value Stream 4

Rating	Nos of Matches	∑ Matches	% Matches
#1	6	9	15%
#2	3		
#3			
#4			
#5	3		
#N/A	6		
Mis-match	42		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%	10				10	10	7170	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.004

Value Stream 5

Rating	Nos of Matches	∑ Matches	% Matches
#1	7	9	15%
#2	2		
#3			
#4			
#5			
#N/A	8		
Mis-match	43		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%			10	10		12	7168	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.001

Value Stream 6

Rating	Nos of Matches	∑ Matches	% Matches
#1	3	5	8%
#2	2		
#3	2		
#4			
#5			
#N/A			
Mis-match	53		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%					24	6	7170	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.002

Figure N3- Photograph 3 - Observed Results versus Fisher Exact Match Test

Photograph 4

Observed Results | **Random Permutations of Operators Data**

Value Stream 1

Rating	Nos of Matches	Σ Matches	% Matches
#1	6	14	23%
#2	8		
#3	2		
#4			
#5			
#N/A	3		
Mis-match	41		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
10.8%		4		160	448	168	6420	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.439

Value Stream 2

Rating	Nos of Matches	Σ Matches	% Matches
#1	1	4	7%
#2	3		
#3			
#4			
#5			
#N/A	9		
Mis-match	47		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.3%			4		16		7180	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.040

Value Stream 3

Rating	Nos of Matches	Σ Matches	% Matches
#1	9	9	15%
#2			
#3			
#4			
#5	1		
#N/A	14		
Mis-match	36		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.6%				10	20	16	7154	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0002

Value Stream 4

Rating	Nos of Matches	Σ Matches	% Matches
#1	10	11	18%
#2	1		
#3			
#4			
#5	4		
#N/A	8		
Mis-match	37		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.5%	10				12	14	7164	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.003

Value Stream 5

Rating	Nos of Matches	Σ Matches	% Matches
#1	4	11	18%
#2	7		
#3			
#4			
#5	1		
#N/A	9		
Mis-match	39		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.6%			10	8	22	6	7154	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0004

Value Stream 6

Rating	Nos of Matches	Σ Matches	% Matches
#1	8	12	20%
#2	4		
#3	2		
#4			
#5	1		
#N/A	2		
Mis-match	43		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.7%			10	10	24	6	7150	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0002

Figure N4- Photograph 4 - Observed Results versus Fisher Exact Match Test

Photograph 5

Observed Results | **Random Permutations of Operators Data**

Value Stream 1

Rating	Nos of Matches	Σ Matches	% Matches
#1		20	33%
#2	20		
#3	1		
#4			
#5			
#N/A	3		
Mis-match	36		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
10.9%	10		10	148	448	168	6416	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.130

Value Stream 2

Rating	Nos of Matches	Σ Matches	% Matches
#1	1	1	2%
#2			
#3			
#4			
#5			
#N/A	18		
Mis-match	41		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.1%						10	7190	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.081

Value Stream 3

Rating	Nos of Matches	Σ Matches	% Matches
#1	2	5	8%
#2	3		
#3	1		
#4			
#5	1		
#N/A	10		
Mis-match	43		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.7%					12	38	7150	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.002

Value Stream 4

Rating	Nos of Matches	Σ Matches	% Matches
#1	5	5	8%
#2			
#3			
#4			
#5	4		
#N/A	7		
Mis-match	44		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%					14	18	7168	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.001

Value Stream 5

Rating	Nos of Matches	Σ Matches	% Matches
#1	1	3	5%
#2	2		
#3			
#4	1		
#5			
#N/A	9		
Mis-match	47		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.3%				4	6	10	7180	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.038

Value Stream 6

Rating	Nos of Matches	Σ Matches	% Matches
#1		0	0%
#2			
#3	3		
#4	4		
#5	2		
#N/A			
Mis-match	51		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.0%							7200	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0

Figure N5- Photograph 5 - Observed Results versus Fisher Exact Match Test

Photograph 6

Observed Results / Random Permutations of Operators Data

Value Stream 1

Rating	Nos of Matches	Σ Matches	% Matches
#1	4	19	32%
#2	15		
#3	2		
#4			
#5			
#N/A			
Mis-match	39		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.8%			30	10	20		7140	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.00002

Value Stream 2

Rating	Nos of Matches	Σ Matches	% Matches
#1	2	3	5%
#2	1		
#3	2		
#4	1		
#5	2		
#N/A			
Mis-match	52		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
10.0%		144		432		144	6480	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.994

Value Stream 3

Rating	Nos of Matches	Σ Matches	% Matches
#1		0	0%
#2			
#3	1		
#4			
#5	1		
#N/A	19		
Mis-match	39		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.0%							7200	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0

Value Stream 4

Rating	Nos of Matches	Σ Matches	% Matches
#1	9	11	18%
#2	2		
#3	1		
#4			
#5			
#N/A	5		
Mis-match	43		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
10.5%	720			4	10	22	6444	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.010

Value Stream 5

Rating	Nos of Matches	Σ Matches	% Matches
#1		1	2%
#2	1		
#3			
#4			
#5	4		
#N/A	5		
Mis-match	50		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.1%						6	7194	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.049

Value Stream 6

Rating	Nos of Matches	Σ Matches	% Matches
#1	3	6	10%
#2	3		
#3	6		
#4	2		
#5			
#N/A			
Mis-match	46		

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
10.1%			144	442		144	6470	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.968

Figure N6- Photograph 6 - Observed Results versus Fisher Exact Match Test

Photograph 7

Observed Results | **Random Permutations of Operators Data**

Value Stream 1

Rating	Nos of Matches	Σ Matches	% Matches		% Matches from 7200 perms.
#1	5	7	12%	⇔	8.4%
#2	2				
#3	3				
#4					
#5	1				
#N/A					
Mis-match	48				

Freq. (∑) permutations with Matches							
		10		148	444	6598	Freq. of Matches
6	5	4	3	2	1	0	Rating

p Value - 0.462

Value Stream 2

Rating	Nos of Matches	Σ Matches	% Matches		% Matches from 7200 perms.
#1	3	3	5%	⇔	0.1%
#2					
#3					
#4	1				
#5					
#N/A	18				
Mis-match	38				

Freq. (∑) permutations with Matches							
			10			7190	Freq. of Matches
6	5	4	3	2	1	0	Rating

p Value - 0.080

Value Stream 3

Rating	Nos of Matches	Σ Matches	% Matches		% Matches from 7200 perms.
#1	3	3	5%	⇔	0.1%
#2					
#3					
#4					
#5					
#N/A	23				
Mis-match	34				

Freq. (∑) permutations with Matches							
			10			7190	Freq. of Matches
6	5	4	3	2	1	0	Rating

p Value - 0.080

Value Stream 4

Rating	Nos of Matches	Σ Matches	% Matches		% Matches from 7200 perms.
#1	6	6	10%	⇔	0.1%
#2					
#3	2				
#4					
#5	1				
#N/A	17				
Mis-match	34				

Freq. (∑) permutations with Matches							
10						7190	Freq. of Matches
6	5	4	3	2	1	0	Rating

p Value - 0.080

Value Stream 5

Rating	Nos of Matches	Σ Matches	% Matches		% Matches from 7200 perms.
#1	7	7	12%	⇔	0.3%
#2					
#3					
#4					
#5	1				
#N/A	25				
Mis-match	27				

Freq. (∑) permutations with Matches							
10					10	7180	Freq. of Matches
6	5	4	3	2	1	0	Rating

p Value - 0.009

Value Stream 6

Rating	Nos of Matches	Σ Matches	% Matches		% Matches from 7200 perms.
#1	4	4	7%	⇔	0.1%
#2					
#3	1				
#4	1				
#5					
#N/A	2				
Mis-match	52				

Freq. (∑) permutations with Matches							
		10				7190	Freq. of Matches
6	5	4	3	2	1	0	Rating

p Value - 0.080

Figure N7- Photograph 7 - Observed Results versus Fisher Exact Match Test

Photograph 8

Observed Results / Random Permutations of Operators Data

	Rating	Nos of Matches	Σ Matches	% Matches	% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 1	#1	4	10	17%	0.6%				14	22	10	7154	Freq. of Matches
	#2	6				6	5	4	3	2	1	0	Rating
	#3	3											
	#4				p Value - 0.0001								
	#5	2											
	#N/A	0											
	Mis-match	45											

	Rating	Nos of Matches	Σ Matches	% Matches	% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 2	#1	2	3	5%	0.3%					10	10	7180	Freq. of Matches
	#2	1				6	5	4	3	2	1	0	Rating
	#3												
	#4				p Value - 0.009								
	#5												
	#N/A	19											
	Mis-match	38											

	Rating	Nos of Matches	Σ Matches	% Matches	% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 3	#1	10	11	18%	0.6%	10			10	8	12	7160	Freq. of Matches
	#2	1				6	5	4	3	2	1	0	Rating
	#3	3											
	#4				p Value - 0.004								
	#5												
	#N/A	11											
	Mis-match	35											

	Rating	Nos of Matches	Σ Matches	% Matches	% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 4	#1	14	16	27%	8.6%	10	4	10	6	144	448	6578	Freq. of Matches
	#2	2				6	5	4	3	2	1	0	Rating
	#3												
	#4	1			p Value - 0.02								
	#5	2											
	#N/A	3											
	Mis-match	38											

	Rating	Nos of Matches	Σ Matches	% Matches	% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 5	#1	5	6	10%	0.4%				14	10	6	7170	Freq. of Matches
	#2	1				6	5	4	3	2	1	0	Rating
	#3	1											
	#4				p Value - 0.006								
	#5	3											
	#N/A	6											
	Mis-match	44											

	Rating	Nos of Matches	Σ Matches	% Matches	% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 6	#1	4	6	10%	0.4%				4	22	4	7170	Freq. of Matches
	#2	2				6	5	4	3	2	1	0	Rating
	#3	4											
	#4	2			p Value - 0.002								
	#5												
	#N/A	5											
	Mis-match	43											

Figure N8- Photograph 8 - Observed Results versus Fisher Exact Match Test

Photograph 9

Observed Results

Random Permutations of Operators Data

Value Stream 1

Rating	Nos of Matches	Σ Matches	% Matches
#1		19	32%
#2	19		
#3			
#4			
#5	2		
#N/A	1		
Mis-match	38		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
11.0%			10	158	478	144	6410	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.165

Value Stream 2

Rating	Nos of Matches	Σ Matches	% Matches
#1	1	1	2%
#2			
#3			
#4			
#5			
#N/A	24		
Mis-match	35		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.1%					4	6	7190	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.080

Value Stream 3

Rating	Nos of Matches	Σ Matches	% Matches
#1		0	0%
#2			
#3			
#4			
#5			
#N/A	20		
Mis-match	40		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.0%							7200	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0

Value Stream 4

Rating	Nos of Matches	Σ Matches	% Matches
#1		0	0%
#2			
#3			
#4			
#5	5		
#N/A	12		
Mis-match	43		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.0%							7200	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0

Value Stream 5

Rating	Nos of Matches	Σ Matches	% Matches
#1		0	0%
#2			
#3			
#4			
#5	4		
#N/A	18		
Mis-match	38		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.0%							7200	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.0

Value Stream 6

Rating	Nos of Matches	Σ Matches	% Matches
#1	1	4	7%
#2	3		
#3	1		
#4	2		
#5			
#N/A	4		
Mis-match	49		

⇔

% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
0.4%					18	12	7170	Freq. of Matches
	6	5	4	3	2	1	0	Rating

p Value - 0.010

Figure N9- Photograph 9 - Observed Results versus Fisher Exact Match Test

Photograph 10

Observed Results | **Random Permutations of Operators Data**

Value Stream	Rating	Nos of Matches	∑ Matches	% Matches		% Matches from 7200 perms.	Freq. (∑) permutations with Matches							
Value Stream 1	#1	5	13	22%	⇔	11.0%				158	456	176	6410	Freq. of Matches
	#2	8					6	5	4	3	2	1	0	Rating
	#3	2												
	#4	2		p Value - 0.515										
	#5													
	#N/A													
	Mis-match	43												
Value Stream 2	#1		2	3%	⇔	0.1%	2					4	7190	Freq. of Matches
	#2	2					6	5	4	3	2	1	0	Rating
	#3													
	#4			p Value - 0.017										
	#5													
	#N/A	6												
	Mis-match	52												
Value Stream 3	#1	3	3	5%	⇔	0.2%					6	10	7184	Freq. of Matches
	#2						6	5	4	3	2	1	0	Rating
	#3	1												
	#4			p Value - 0.005										
	#5	3												
	#N/A	10												
	Mis-match	43												
Value Stream 4	#1	7	8	13%	⇔	0.6%					4	36	7160	Freq. of Matches
	#2	1					6	5	4	3	2	1	0	Rating
	#3	2												
	#4	2		p Value - 0.0										
	#5													
	#N/A	3												
	Mis-match	45												
Value Stream 5	#1	0	1	2%	⇔	0.1%					4	6	7190	Freq. of Matches
	#2	1					6	5	4	3	2	1	0	Rating
	#3	1												
	#4	1		p Value - 0.080										
	#5	4												
	#N/A	1												
	Mis-match	52												
Value Stream 6	#1		7	12%	⇔	10.4%				720	4	22	6454	Freq. of Matches
	#2	7					6	5	4	3	2	1	0	Rating
	#3	2												
	#4			p Value - 0.956										
	#5													
	#N/A													
	Mis-match	51												

Figure N10- Photograph 10 - Observed Results versus Fisher Exact Match Test Figure

8.15 Appendix O – Visual Workplace

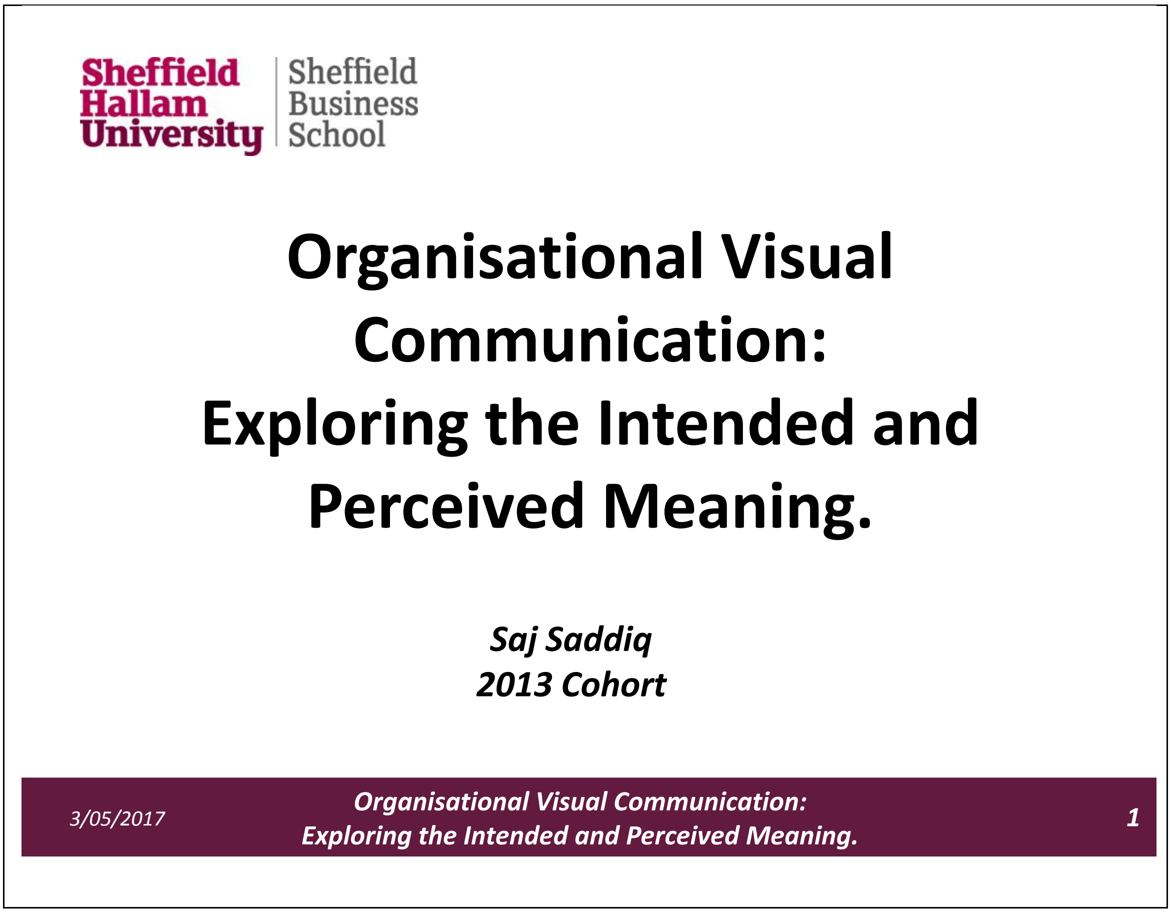
The list of 20 elements shown below is a summary of those identified by Greif (1991). He identified six broad shop-floor related themes which were then further broken down into twenty sub-elements. The document shown below was issued to each of the six manages prior to them being asked to complete their participant-led-photography activity, as a guide to what type of visual communication they could consider.

(1) Identification of territory
(2) Identification of equipment such as machines, tools and maintenance equipment
(3) Identification of the team. Personnel associated with each cell or production line
(4) Markings on the floor
(5) Marking of tools and racks. Guidance for tool and product placement and identification
(6) Technical area. Auxiliary documentation that gives support to the cell or line
(7) Communication and rest areas, with information billboards
(8) Display of cleaning elements and instructions for their use in the cell or line
(9) Manufacturing instructions and technical procedures
(10) Maintenance guidelines
(11) Computer terminal
(12) Production schedule
(13) Maintenance schedule
(14) Physical identification of raw materials, work in progress and finished product inventories
(15) Monitoring signals for products and processes
(16) Statistical process control (SPC)
(17) Register of problems
(18) Objectives, results and deviations
(19) Visibility of improvement activities such as actions taken
(20) Company mission and vision statements; quality, environment and safety policies

Figure O1 - Guidance for Participant-Led-Photography (Greif 1991, p20-21)

8.16 Appendix P – Dissemination – Research Participants

A summary presentation (shown below) was prepared and delivered to the managers that directly contributed to this research. This comprised a one hour presentation seminar. The purpose was to provide an opportunity for the participating managers to see the results of the research as well as ask questions.



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My Background

- 26 years in Automotive Components Manufacturing.
- Background – Manufacturing Engineering / Project Management / Engineering Management.
- 12 Years - contributing to defining and deploying my companies operating system – including Visual Communication.
- Generally cut and paste from other (similar) organizations – best practice thinking….increasingly using theory to inform the way forward.
- Visual Communication seems to work – but why?
- Powerful means of orientating organisational actors towards particular goals (Greif 1991).
- Which theories can inform its practice?
- Is it effective?
- How can it practically be improved?

Visual Communication is an artefact of some intention by management.

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Central Question

My hunch - Visual Communication is being used to “control” shop-floor activities in my organization.

Aim:
- To measure the level of correlation between the intended and interpreted meaning of visual communication.

Objectives:
- To extract (elicit) psychological constructs from managers who author the visual communication utilised on the shop-floor.
- To use these psychological constructs to create a measurement instrument to enable an exploration of the intended and interpreted meaning of visual communication.
- To conduct this research using methods consistent with neo-positivist research.

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Visual Communication - Definition

Communication:
- It is a process of shaping knowledge to information by one cognitive system, the transfer through some medium and the subsequent interpretation by a second cognitive system (Lenski 2010).
- Intentional use of symbols by one person to send a message – others interpreting that message and responding (Keeney 2009).
- A social process that involves the interaction between two people, where typically one person at least cares to communicate a message to another (Keeney 2009).

Visual Communication
- Process of exchange of messages that includes visuals.
- It is a process because it consists of a series of communication acts or exchanges where one person is using symbols to send a message and the meaning of this message is understood in some way by the other and they are able to respond (Keeney 2009).
- Visual communication differs from Visual Display - because the intended message interpretation is an objective - not just an expression of the feelings and thoughts of the author.

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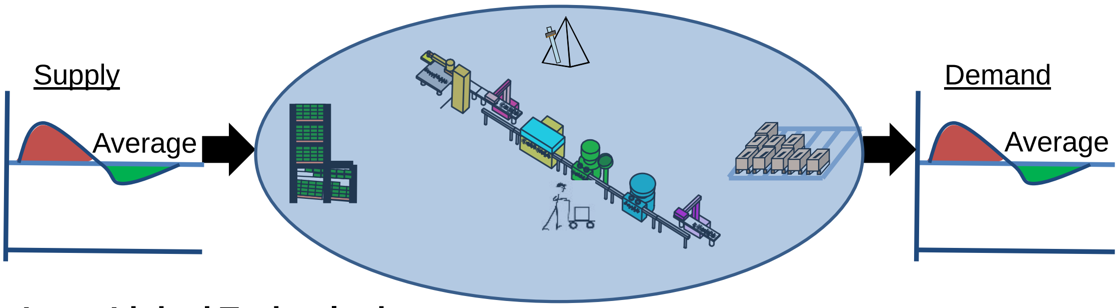
Background



Long-Linked Technologies
- High investment / mass production.
- Cause & effect relations of input and output, well defined.
- Stable supply of inputs (materials, labour).
- Continuing demand for standardized outputs, products (Scott 1992).

Technical Core
- Effectively sealed off from the environment - to affect stability.
- Buffering, Levelling, Forecasting, Rationing (Thompson 2004).

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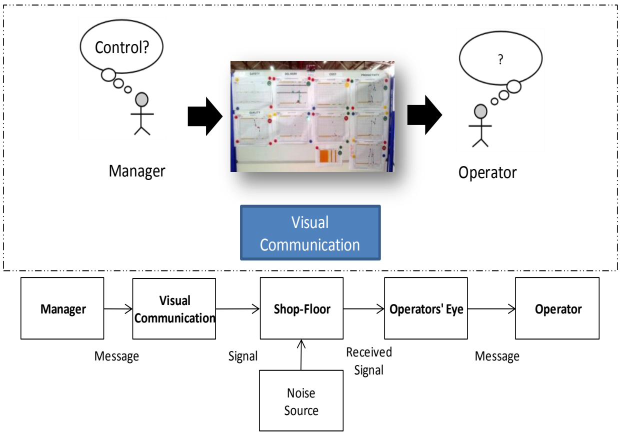
Conceptual Model



Underpinning thoughts

- Premise - visual communication in the context of a hierarchical bureaucratic organisation.
- Visual communication on the shop-floor is motivated in the first instance by some thought in the mind of the manager.

Shannon & Weaver Communication Model

- "…the communication process begins when a message is conceived by a sender. It is then encoded – translated into a signal or sequence of signals – and transmitted via a particular medium or channel to a receiver, who then decodes it" (Watson & Hill 2012, p48).

Based on the Shannon & Weaver Communication System Model (Shannon & Weaver 1949, p4).

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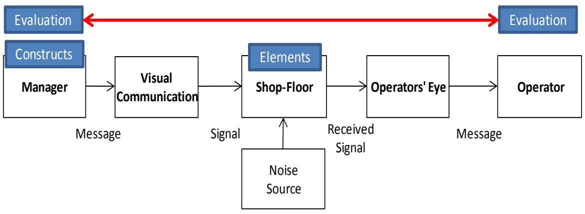
Research Design

Repertory Grid Analysis

- Based on Personal Construct Theory (George Kelly) – used to elicit psychological constructs (personal theories used to make judgements). Used in this research to capture the motivation of managers for the use of specific visual communication.



- There are three core features of the Repertory Grid Analysis technique that are common and remain constant irrespective of any modifications (Bauman 2015, Winter 2013):
  - Elements,
  - Constructs and
  - Evaluation

Elements

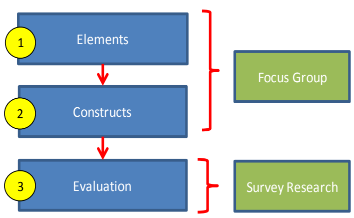
- These elements were a number of photographs of examples of visual communication currently used on the shop-floor.

Constructs

- "…explanations of elements characteristics" (Bauman 2015, p369,)
- Elicited directly from the managers in relation to the photographs of visual communication.

Evaluation

- Constructs used to create a measurement instrument.
- Subsequent administration to two groups enables comparison between.
- Accessing the intended & interpreted meaning of visual communication.



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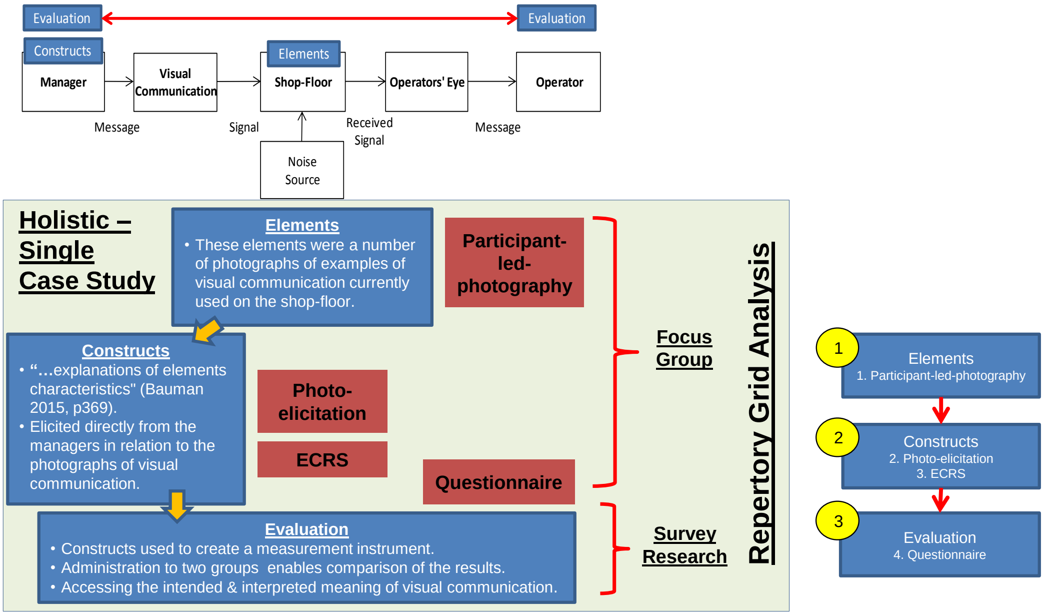
Research Methods



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Findings

Visual Communication

- Consistent with expectations for mass production, long-linked technology (Schmidt 2005):
  - Inventory,
  - Demand Information,
  - Capacity (Schmidt 2005).
- Further…..bound to sub-environments & respective imperatives….from managers perspective.
  - i.e. safety focus (value stream one), profit focus (value stream three), scheduling focus (value stream six).
- Two main groups, a possible third:
  1. Highly standardised: titles, labels, policies for upkeep and usage – higher rating – **cosmopolitan** visual communication.
  2. Poorly standardised – often poorly defined and/or labelled. However regular usage within/across the value streams provides a somewhat settled meaning – communication recognised within its context – medium rating - **metropolitan** visual communication.
  3. Visual communication used within value streams – poorly labelled, not incorporated into policies, even limited familiarity within the value streams for their usage – poor rating – **provincial** visual communication.

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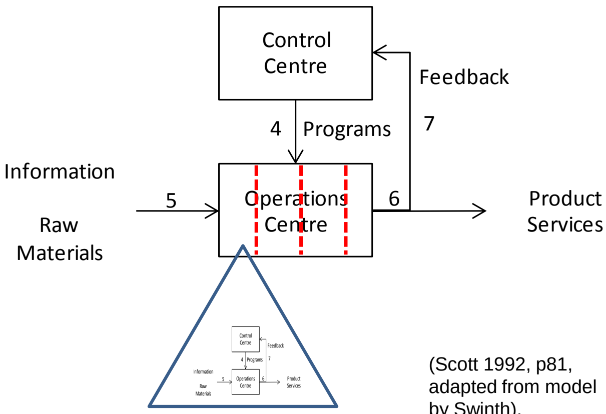
Discussion

Organisational Imperatives

- Mass Production – Inventory, Demand Information, Capacity (Schmidt 2005):
  - **Machine Isolation Procedure** – H&S policies (4).
  - **Production Planning Board** – Information Input (5).
  - **Communication Board** – Performance review / regulation / diagnostics (6)



Recursive

(Scott 1992, p81, adapted from model by Swinth).

Performance Management Systems Literature – does not seem to clearly recognise differentiation of shop-floor. Similarly with Visual Management literature.

- Viable System Model (Beer 1984). Element of 'Implementation' - production of goods (or services), and a local management responsible for the daily optimisation and control (Dominici & Palumbo 2013).

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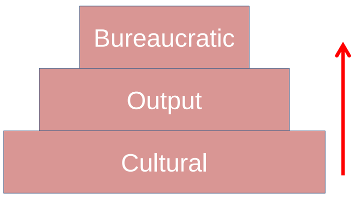
Discussion – Cont'd



Control

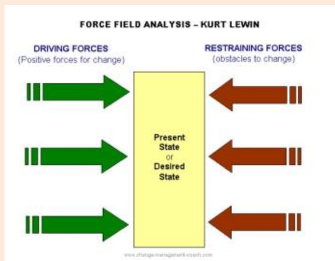
- Visual communication to work at a bureaucratic level of control requires cultural control. Bureaucratic control requires "...social agreement on a broad range of values and beliefs" (Ouchi 1979, p838), i.e. cultural control…..?

'Output' is foundational to Bureaucratic control (Ouchi 1979). Is Cultural control invisible but nonetheless operating to underpin both?

Static or Dynamic Stability

The role of visual communication for stability and regulation.

-VS-



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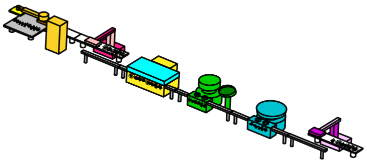
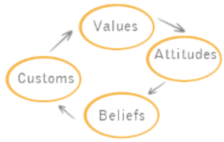
Discussion – Cont'd

Bureaucratic Control 行政控制:

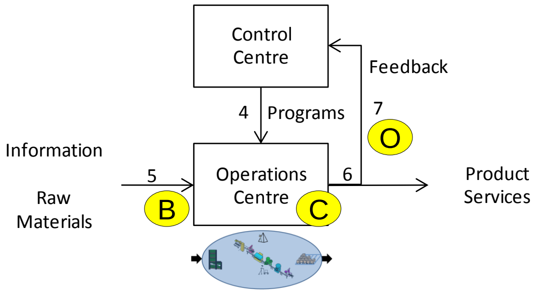
- Objective impersonal rules and procedures
  不带个人色彩的客观规则和程序
- Specifies the 5W+1H of the transformation process
  指定变革过程的5W1H
- Rationally designed by hierarchical superiors层级制度的合理设计





Output (Market) Control

- Metrics and indicators – identifying what is good or bad performance.



Cultural Control 文化控制:

- Attempt to influence employees subjective norms and values试图影响员工主观标准和价值观.
- To align employees commitment to organizational goals
  要使员工承诺和组织目标一致
- Generation and maintenance of a shared culture创造和维护一个共同文化

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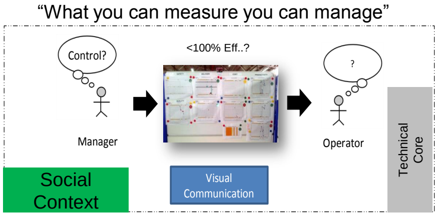
Conclusion

- Visual Communication - Powerful means of orientating organisational actors towards particular goals (Greif 1991).
- Specific focus
  in this research – Managers → Operators.
- Quantitative rating – intended versus perceived.
- Highlighting that management contingencies inform and motivate the message.

"What you can measure you can manage"



Contribution

- **Organisational Theory** – measuring communication effectiveness enables crafting of the visual communication.
- **Management Theory** – enables managers to measure communication within its situated context. Informs their ability to affect control.
- **Methods**
  - **Repertory Grid Analysis** – novel, structured approach. Sympathetic to organisational structure (differentiation, hierarchy).
  - **Participant-Led-Photography** – engaging, easy to use, empowering.
  - **Photo-Elicitation** – use of natural language, empowering.
  - **Eliminate, Combine, Re-arrange, Simplify** – empowering, reduce miss-interpretation, timeliness.

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Strengths - Limitations

	Strength	Weakness

Case Study - Single	• Testing theory within its context – visual communication cannot be separated.
	• Fits the criteria for a single case study:
	  • Case represents a typical case.
	  • When the case study will be revelatory.
	• Conducted within a developed lean site.
	• English speaking.
	• 1:1 administered interviews.
	• Low contact time required.
	• Methodological approach for local understanding and possible local optimisation.
		• Outcome restricted to context of the questionnaire.
		• Relatively closed environment (not tested elsewhere).

Photo-Elicitation	• Relatively closed
	  • Few key imperatives.
	  • Constructs built through replication.
		• What about more open environment? Is it sensitive enough?
		• Low resolution complexity).
		• Low diversity environment.

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Future Research

- Longitudinal Research
- Hierarchy → Production Manager Level
- Case Studies -

	Intensive*	Mediating*	Long-Linked*
UK	✗	✗	✓
None UK	✗	✗	✗

(*Thompson 2004)

- Conceptual Model

	Assumptions	Options selected	Future
Process ✓	• Communication as a Message. • Privileging the sender over the receiver. • Efficiency ≤ 100%	• Exact Match analysis (1,2). • Differentiation by value stream.	• Operator versus operator. • Manager versus Manager. • Across value streams
Semiotics	• Negotiated Meaning		• Efficiency > 100%?

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My Future

- To write two papers from this thesis.
- To continue with academic development through research.
- Contribute to system theory (lean theory) through research and practice.

3/05/2017 *Organisational Visual Communication: Exploring the Intended and Perceived Meaning.* 16

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My hunch - Visual Communication is being used to "control" shop-floor activities in my organization.

Questions?

3/05/2017 *Organisational Visual Communication: Exploring the Intended and Perceived Meaning.* 17

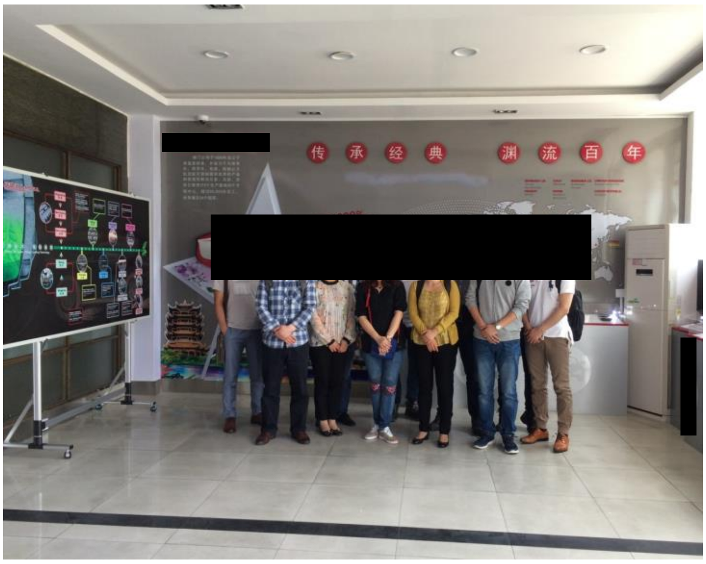
8.17 Appendix Q – Dissemination – Lean Practitioners

A half-day workshop, comprising a mixture of class room based theory and exercises as well as shop-floor activity is shown below. This was presented to a group of Lean trainees within the wider Automotive Corporation that could benefit from the findings. For this group it was necessary to distil the key findings from the research and present it in the form of a workshop, as these managers are expected to practically implement Lean theory in their respective sites.

Visual Communication Workshop

Following Presentation used to conduct workshop: 26th April 2017 – Location: Wuhan (China)

Site	Name	Department
Chongqing - China	S.C.	Logistics Department
Chongqing - China	L.R.	Human Resources
Chongqing - China	H.W.	Manufacturing Engineering.
Chongqing - China	L.Z.	Production Manager
Chongqing - China	E.B.	Lean Manager
Prospecton –South Africa	R.G.	Production Manager
Wuhan - China	A.Y.	Lean Manager
Wuhan - China	X.Z.	Production Manager
Wuhan – China	S.G.	Logistics Mgr
Purchasing - China	J.L.	Purchasing – Shanghai
Purchasing - China	J.W.	Purchasing - Shanghai
Qingdao – China	L.S.	Mfg Engineer



Operations Excellence Group / Braking   Data classification: Internal   26/4/2017   2

[redacted]

Visual Communication / Management / 可视 化沟通/管理

April 2017

[redacted]

Workshop Rules – Suggestions /研讨会规则 - 建议

- One person speaks at a time /同一时间只有一个人说话
- **Respect for each other /**尊重对方
- Punctuality /准时
- Involvement /投入
- Equality /平等
- Phones / Blackberry – use outside of the room please. /电话/黑莓 – 请到室外使用。
- No laptops (one exception!) /没有笔记本电脑（一个除外！）
-

Multi-Tasking is a LIE!
This is a lean workshop so we will (try to) follow "single-piece-flow"
多重工作同时处理是骗人的！
这是精益研讨会，所以我们将（尝试）遵循"单件流"

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Visual Communication 可视化沟通

- In a visual organization, it is possible to understand the **flow** and **status** of activities quickly and simply through observation (without receiving verbal indications).在一个可视化组织里，通过观察（而不接收口头指示），就可以快速和简单地了解活动的流程和状态。
- This situation promotes self-management - avoiding the need for micro-supervision of the operator. 这种情况下，促进自我管理 - 避免了对操作人员的密切监督的必要性
- It is about **CONTROL** built into the fabric of the work environment 它是织于工作环境内的控制

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Visual Control – Definition/视觉控制 - 定义

Communication / 通讯:

- It is a process of shaping knowledge to information by one cognitive system, the transfer through some medium and the subsequent interpretation by a second cognitive system (Lenski 2010). 它是由一个认知系统，通过一些介质的转移和由第二认知系统随后解释（ 伦斯基 2010） 成形知识信息的处理 。
- Intentional use of symbols by one person to send a message – others interpreting that message and responding (Keeney 2009). 由一个人故意使用符号来发送消息 - 其他人解释该消息和响应 （2009 Keeney ）。
- A social process that involves the interaction between two people, where typically one person at least cares to communicate a message to another (Keeney 2009). 涉及两个人， 其中一个典型的人至少在乎的消息传达给另一个（2009 Keeney）之间的相互作用 一个 社会过程。

Visual Communication / 视觉交流:

- Process of exchange of messages that includes visuals. 包含视觉效果的消息交换过程。
- It is a process because it consists of a series of communication acts or exchanges where one person is using symbols to send a message and the meaning of this message is understood in some way by the other and they are able to respond (Keeney 2009). 这是一个过程，因为它包含一系列通信行为或交换，一个人正在使用符号发送消息，并且该消息的含义以某种方式被另一方理解，并且他们能够做出响应（Keeney 2009）。
- Visual communication differs from Visual Display - because the intended message interpretation is an objective - not just an expression of the feelings and thoughts of the author. 视觉传播与视觉显示不同 - 因为预期的消息解释是一个目标 - 而不仅仅是表达作者的感受和想法。

LENSKI, W. (2010). Information: A Conceptual Investigation. Information, 1(2), 74-118.
KENNEY, K. (2009). Visual Communication Research Designs. Routledge.

Visual Communication
可视化沟通

- Sharing of key standard information through visual means - eliminating the need for discussion
  通过可视化方式的关键标准信息共享 – 消除讨论的必要性
- Allows for允许::
  - Quick detection of normal and abnormal conditions
    正常和异常情况快速探测
  - Efficient communication – reducing misunderstanding
    有效的沟通 - 减少误解
- Visual Communication underpins many aspects of Management Systems and in turn Leader Standard work.可视化沟通支撑管理系统的多个方面，进而支持领导者标准工作。
- Use paper 用纸张

Use paper-based &/or visual means for communication. Avoid IT solutions – especially if it moves people away from the workplace.

Why Visual Management?
为什么要可视化管理?

<u>People record information by 人们通过以下方式记录信息:</u>

Sight视觉: 83 %

Hearing听觉: 11 %

Smell嗅觉: 3,5 %

Touch触觉: 1,5 %

Taste味觉: 1 %

Visual is very important 视觉是非常重要的!

Power of Visual Communication
可视化沟通的力量

What do these signs mean？

这些标识意味什么?

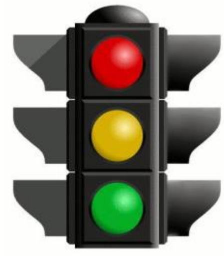
What’s inside these cans?

这些罐子里有什么?

Power of Visual Communication
A Universal Language
可视化沟通的力量--通用语言

Regardless of the country, the culture, the language！
无论国家，文化，语言！

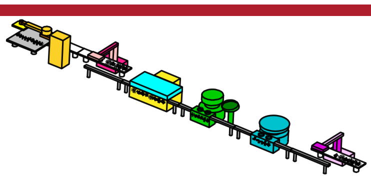


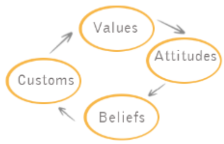




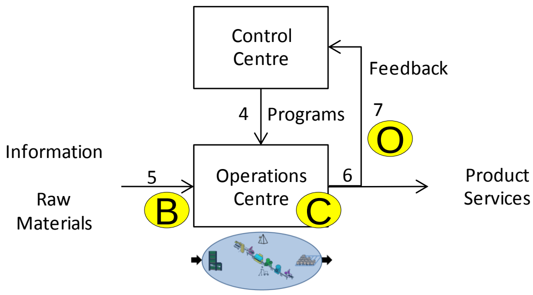
Visual communication is purposeful.....types of CONTROL
可视化沟通是有目的类型的控制

Bureaucratic Control 行政控制:
- Objective impersonal rules and procedures
  不带个人色彩的客观规则和程序
- Specifies the 5W+1H of the transformation process
  指定变革过程的5W1H
- Rationally designed by hierarchical superiors层级制度的合理设计





Output (Market) Control
- Metrics and indicators – identifying what is good or bad performance.



Cultural Control 文化控制:
- Attempt to influence employees subjective norms and values试图影响员工主观标准和价值观.
- To align employees commitment to organizational goals
  要使员工承诺和组织目标一致
- Generation and maintenance of a shared culture创造和维护一个共同文化

MCAULEY, John, JOHNSON, Philip, DUBERLEY, Joanne. (2014). Organization Theory: Challenges and Perspectives. Harlow, Pearson. (Electronic edition).

Visual communication is purposeful.....types of CONTROL
可视化沟通是有目的类型的控制

Visual Communication 视觉交流

- Used for critical elements that must be controlled for mass production, long-linked technology (Schmidt 2005): 用于批量生产，长链技术必须控制的关键元素:
  - Inventory, 库存，
  - Demand Information, 需求信息,
  - Capacity (Schmidt 2005). 容量
- Further … ..bound to sub-environments & respective imperatives … .from managers perspective. 另外 … ..bound子环境和相应的迫切需要 。从 … 角度的经理。
  - i.e. safety focus (value stream one), profit focus (value stream three), scheduling focus (value stream six). 即安全重点（价值流一），利润重点（价值流三），调度重点（价值流六）。
- Two main groups, a possible third: 两个主要群体， 一个可能的第三个：
  1. Highly standardised: titles, labels, policies for upkeep and usage – higher rating – 高度标准化的：标题，标签，用于维护和使用策略 - 较高的评价 - **cosmopolitan** visual communication. 世界性的 可视通信。
  2. Poorly standardised – often poorly defined and/or labelled. 差的标准化 - 通常被定义和/或标记的差。However regular usage within/across the value streams provides a somewhat settled meaning – communication recognised within its context – medium rating - **metropolitan** visual communication. 在整个价值流中/但是经常使用提供了一定程度上定居的意义 - 其通信范围内的认可 - 媒体评价- 大都市的 视觉传达。
  3. Visual communication used within value streams – poorly labelled, not incorporated into policies, even limited familiarity within the value streams for their usage – poor rating – 价值流中使用视频通信 - 不良标记，价值流，其使用范围内未纳入政策，即使是有限的熟悉 - 等级差 - **provincial** visual communication. 省 可视通信。

SCHMIDT, Glen, M. (2005). The OM Triangle. Operation Management Education Review. Senate Hall Academic Publishing. 1(1), 87-104

Visual Control v Visual Information Shop-floor Environment
可视化控制v可视信息 ---- 车间环境

Bureaucratic Control
行政控制

Bureaucratic

Output

Cultural

Cultural Control
文化控制

Process Control 过程控制

Project Control 项目控制

Member Management 团队成员管理

Member Information 成员资料

Visual Control
可视化控制

Visual Information
可视化信息

Control /控制

- Visual communication to work at a bureaucratic level of control requires cultural control. 视觉传播在官僚主义的控制层面上工作需要文化控制。
- Bureaucratic control requires "...social agreement on a broad range of values and beliefs" (Ouchi 1979, p838), ie cultural control … ..? 官僚控制要求"在广泛的价值观和信仰的......社会协议"（ 大内 1979年， P838）， 即文化控制 … ..?

OUCHI, W. G. (1979). A Conceptual Framework for the Design of Organizational Control Mechanisms. In Readings in Accounting for Management Control (pp. 63-82). Springer US.

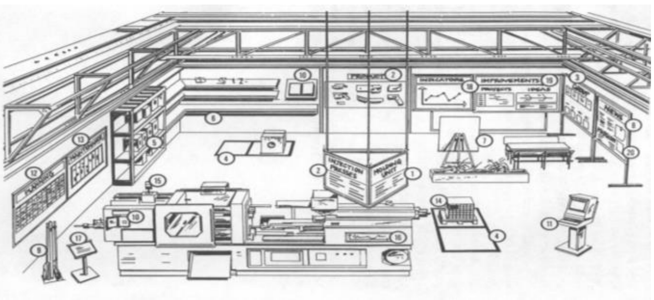
Four functions of Visual Control
可视化控制的四大功能

1. **Member Engagement** 成员参与
   - Almost 100% information, i.e. Future plans
     几乎100%的信息，即未来计划
   - May LOOK like control, i.e. Collective salary status
     可能看起来像控制，即集体工资状态
   - Involvement and responsibility (pictures etc)参与和责任(图片等)

2. **Member Management** 团队成员管理
   - Mainly information, i.e. Job versatility, member job allocation
     主要信息，如多功能的工作，成员工作分配
   - May have elements of control, i.e. Absence tracking
     可能有控制的要素，即缺乏跟踪
   - May be used for "feel the need" – kaizen ideas tracking
     可用于"觉得有必要" - 持续改善的点子追踪

3. **Project control**项目控制
   - Mainly control, i.e. Project status against plan
     主要是控制，即对应计划的项目状态
   - May have elements of information ABOUT the project
     可能有关于项目的信息要素
4. **Process control**过程控制
   - Visual control in its purest form
     可视化控制在其最纯粹的形式

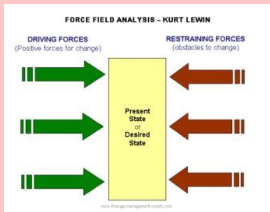
Visual Communication
Typical Sub-Elements
可视化沟通 典型的子要素



Static or Dynamic Stability

The role of Visual Communication for stability and regulation.

-VS-



CORE ELEMENTS of Visual Communication within the workplace工作场所中的可视化沟通的核心要素:

Team Territory团队区域::
1. Identification of territory 区域标识
2. Identification of activities, resources, and products 活动，资源和产品标识
3. Identification of the team 团队标识
4. Markings on the floor 地面上的标识
5. Marking of tools and racks 工具和机架标识
6. Technical area 技术领域
7. Communication area and rest area 交流区和休息区
8. Information and Instructions 信息和说明
9. Neatness (broom) 整洁(扫帚)

Visual Documentation 可视化文档
10. Manufacturing instructions and technical procedures
    生产指导书和技术程序

Visual Production Control 可视化生产控制
11. Computer Terminal计算机终端
12. Productions Schedule 生产计划
13. Maintenance Schedule 维护计划
14. Identification of inventories and work-in-process
    库存和在制品标识

Visual Quality Control 可视化质量控制
15. Monitoring signals for machines 机器监控信号
16. Statistical process control (SPC) 统计过程控制(SPC)
17. Record of problems问题记录

Displaying Indicators 显示指标
18. Objectives, results, and differences目标，结果和差异

Rendering Progress Visible 表现过程的可视化
19. Improvement activities 改进活动
20. Company project and mission statement 公司的项目和任务书

Greif, M. (1991). The visual factory: building participation through shared information. Productivity Press.

Visual Communication - 20 Sub-Elements…..Example
可视化沟通 -20个子要素… ..例子

Team Territory团队区域:
1. Identification of territory 区域标识
2. Identification of activities, resources, and products 活动，资源和产品标识
3. Identification of the team 团队标识
4. Markings on the floor 地面上的标识
5. Marking if tools and racks 工具和机架标识
6. Technical area 技术领域
7. Communication area and rest area 交流区和休息区
8. Information and Instructions 信息和说明
9. Neatness (broom) 整洁(扫帚)

Visual Documentation 可视化文档
10. Manufacturing instructions and technical procedures 生产指导书和技术程序

Visual Production Control 可视化生产控制
11. Computer Terminal计算机终端
12. Productions Schedule 生产计划
13. Maintenance Schedule 维护计划
14. Identification of inventories and work-in-process 库存和在制品标识

Visual Quality Control 可视化质量控制
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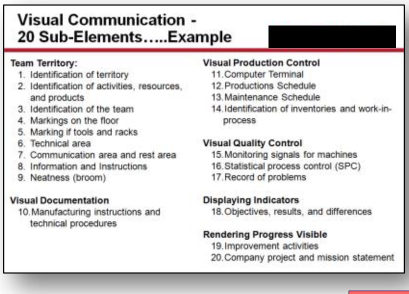
Rendering Progress Visible 表现过程的可视化
19. Improvement activities 改进活动
20. Company project and mission statement 公司的项目和任务书

GREIF, Michel (1991). The Visual Factory: Building Participation through shared Information. Productivity Press. Portland OR

Exercise – Activity
练习 - 活动

Team / 团队 – A	Team / 团队 - B	Team / 团队 - C	Team / 团队 - D

[redacted]


Visual Communication - 20 Sub-Elements…..Example [redacted]

Team Territory:
1. Identification of territory
2. Identification of activities, resources, and products
3. Identification of the team
4. Markings on the floor
5. Marking if tools and racks
6. Technical area
7. Communication area and rest area
8. Information and Instructions
9. Neatness (broom)

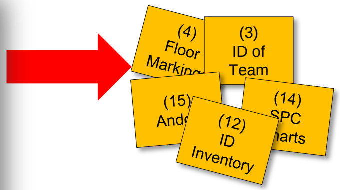
Visual Documentation
10. Manufacturing instructions and technical procedures

Visual Production Control
11. Computer Terminal
12. Productions Schedule
13. Maintenance Schedule
14. Identification of inventories and work-in-process

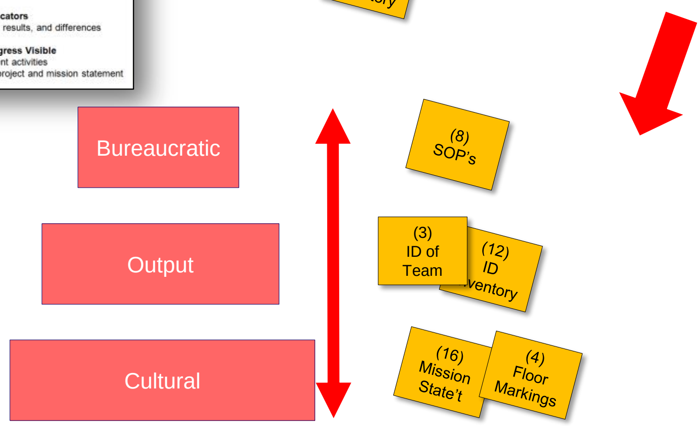
Visual Quality Control
15. Monitoring signals for machines
16. Statistical process control (SPC)
17. Record of problems

Displaying Indicators
18. Objectives, results, and differences

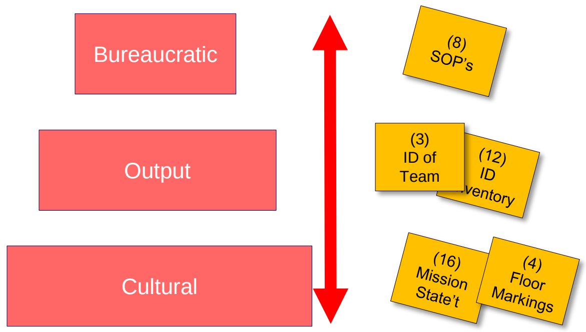
Rendering Progress Visible
19. Improvement activities
20. Company project and mission statement



Team Activity团队活动:
Put one item per post-it and place on this line
每一张告示贴一个项目，放到线上相应位置



Exercise – Activity
练习 - 活动

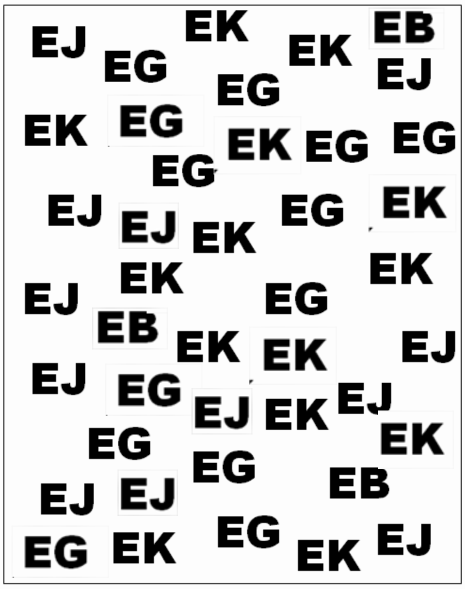


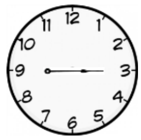
Team Activity团队活动::

Has each team got the same answer 每个团队得到了同样的答案吗？
What does this mean 这意味着什么？
Do we consider ***why*** we are using VC 我们考虑到为什么我们使用VC吗？

Benefits of Visual Management
可视化管理的好处

Visual Management Test
可视化管理测试

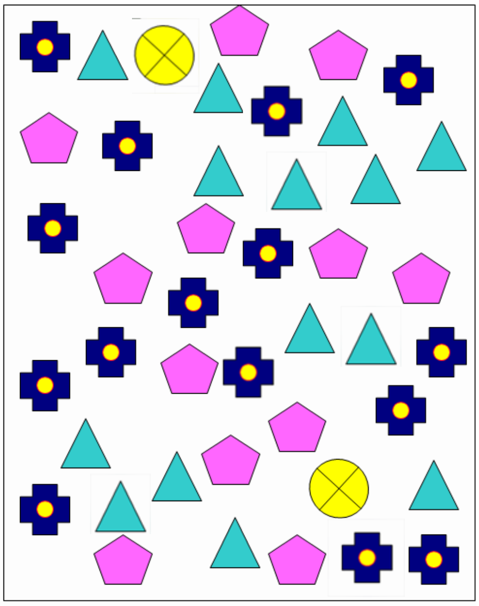


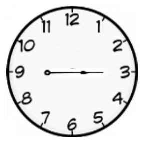


On “GO” count the数一数:

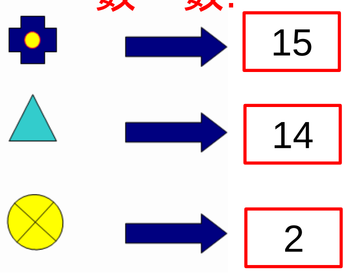
EJ	→	12
EG	→	13
EB	→	3

Visual Management Test
可视化管理测试



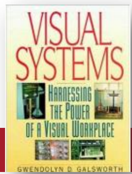


On “GO” count the 数一数:



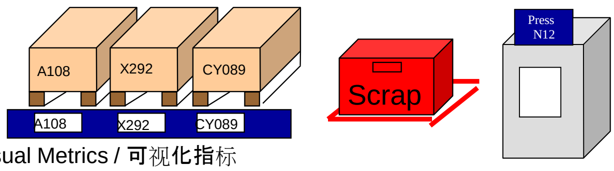
Creating a Visual Management System创建可视化管理系统

- To create a visually managed factory a 4 stage process can be adopted
  为创建可视化管理的工厂，可以采用4阶段过程
- The 4 stages are to progressively implement
  4阶段过程可以渐进式推进。

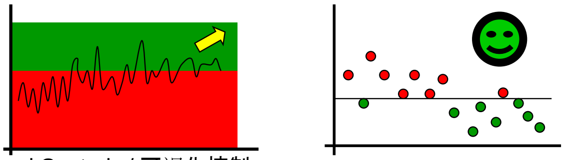


1 – Workplace organisation – 5S / 工作场所的组织 - 5S

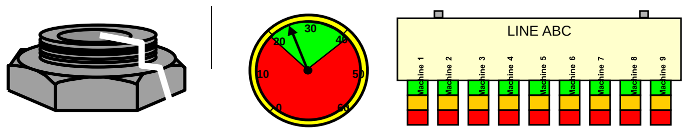
2 – Visual Displays & Escalation rules / 可视化显示和升级规则



3 – Visual Metrics / 可视化指标



4 – Visual Controls / 可视化控制



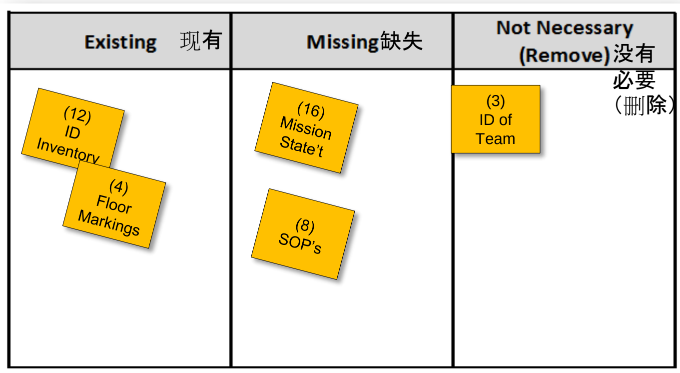
Galsworth, G. D. (1997). Visual systems: harnessing the power of the visual workplace. American Management Association.

Exercise – Activity/ 练习 - 活动

Team / 团队 – A	Team / 团队 - B	Team / 团队 - C	Team / 团队 - D
[redacted]			

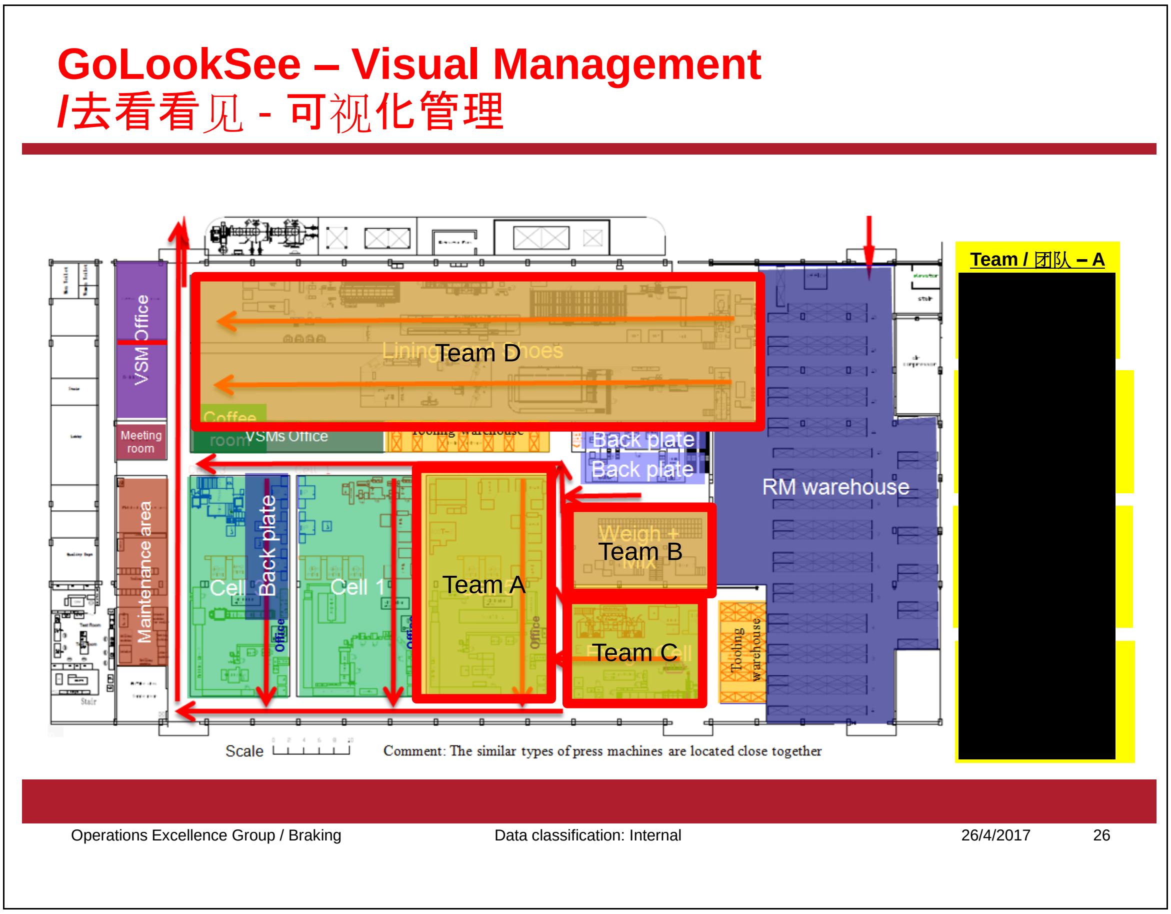
Team Activity/团队活动:

- Use the above post-it notes again.
  再次使用以上告示贴
- Go to your respective AREA/
  到各自的区域:



- What visual control elements exist already/
  已经存在什么样的可视化控制要素?
- What are missing/缺失什么?
- What are unnecessary (exist already but not required)/
  什么是不必要的（已经存在但没有必要）

http://www.visual-literacy.org/periodic_table/periodic_table.html



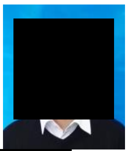
8.18 Appendix R – Dissemination – Newsletter

Below is shown a copy of a newsletter prepared for global transmission in June 2017. This is a quarterly newsletter that is used to communicate the progress of lean implementation across the organisation. This newsletter is made available to all 17 sites, to staff and direct hourly workers.

[redacted] News

[redacted]

Global [redacted] Newsletter – Issue #4



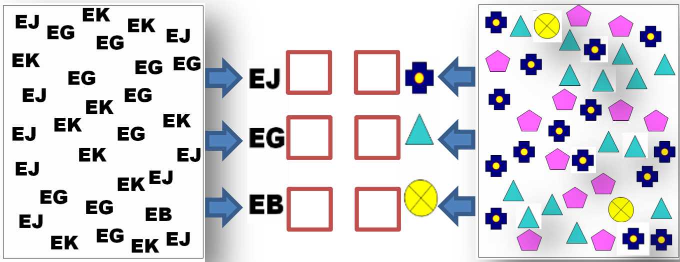
[redacted] Plant Manager – (China) Wuhan Plant

Welcome to edition of the Global FMOS Newsletter. I want to keep you informed about the [redacted]. In this edition I will speak about the role that Visual Communication plays in helping us to maintain a safe and productive work environment. I will also mention the FMOS 2017 Lean Expert Program, which is now running in its third year, and is helping us to implement best practice techniques by training the plant staff in FMOS thinking.

People record information by:

- Sight: 83 %
- Hearing: 11 %
- Smell: 3.5 %
- Touch: 1.5 %
- Taste: 1 %

Quiz – Count the letters. Write down the totals. Repeat for the shapes. Which is easier?



Answer - EJ=9, EG = 10, EB = 1. [flower]=15, [triangle]=14, [circle]=2.

Power of Visual Communication - A Universal Language!

- **In a visual organization, it is possible to understand the flow and status of activities quickly and simply through observation (without receiving verbal indications.**
- **This situation promotes self-management - avoiding the need for micro-supervision.**
- **It is about building CONTROL into the fabric of the work environment**

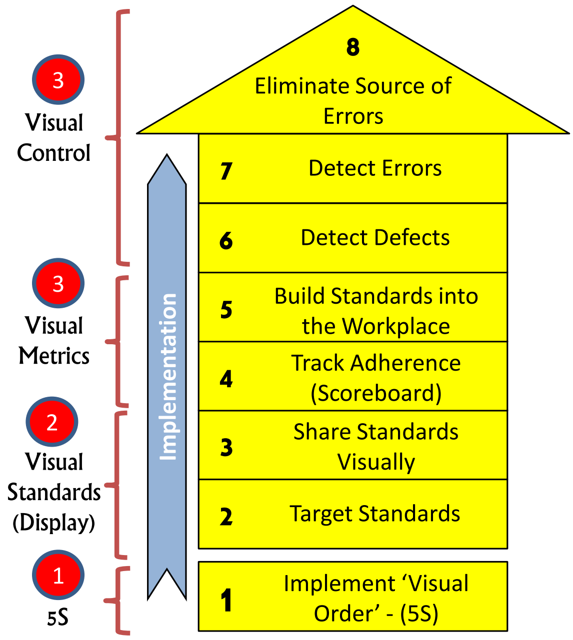
Visual Communication – Cont'd

"A Visual Workplace – is a work environment that is self-explaining, self-ordering, self-regulating, and self-improving – where what is supposed to happen does happen, on time, every time, day or night".

(Galsworth, G. D. (1997). Visual systems: harnessing the power of the visual workplace. American Management Association).

- **To create a visually managed factory a 4 stage process is adopted.**
- **The 4 stages are to progressively implement:**
  - **5s**
  - **Visual Standards**
  - **Visual Metrics**
  - **Visual Controls**

Blueprint for a Visual Workplace

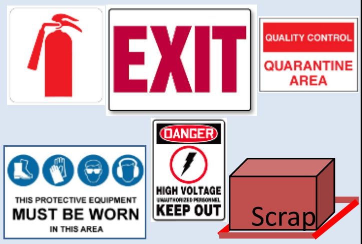


5s - This is the 1st step of implementing visual management.

Visual Displays –

Make the workplace environment communicate certain standards, i.e.

- Safety Equipment, Cell Perimeters, Storage Locations, Quality, etc.



Visual Metrics –

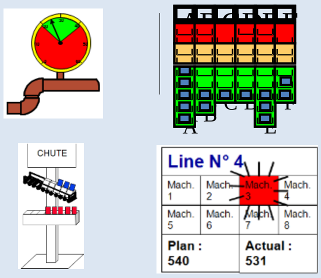
Make performance visible, i.e.

- graphs, paretos, action plans. Ideally using colors, symbols, smileys, arrows, etc…

Visual Control –

Build standards into the processes, allowing OK / NOK to be detected directly, i.e.

- Visual aids on machine such as alerts, visual scheduling, etc.



Lean Expert Training – Class of 2017

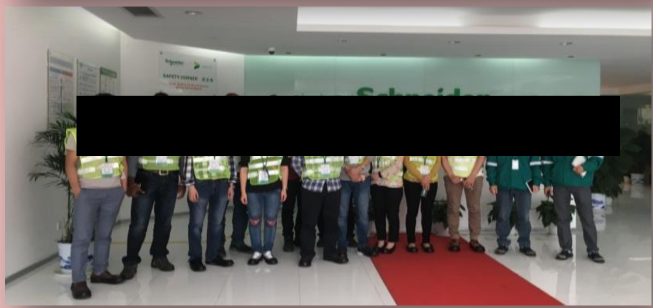
Class of 2017 - Lean Expert Delegates

We are continuing to train members from plant and central functions to better understand how to use the tools within FMOS. This spreads the necessary knowledge and skills so that we can continue to deploy FMOS in the right way.

In China the 2017 Lean Expert Training is currently on-going, with two training weeks having been completed at the [redacted]e.

Delegates during week 2 Training at Wuhan

[redacted]



Delegates visited the local Schneider Electric Company (Wuhan) :
This gave our members the opportunity to discuss and observe the Schneider Operating system.

8.19 Appendix S – Dissemination – Executive Summary

Shown below is an executive summary of this research. This was prepared for the executives of the company that have sponsored my research and can affect the use of visual communication throughout the organisation.

Sheffield Hallam University

Visual Communication: A Methodology for Measuring the Management Intention and Shop-Floor Acknowledged Meaning.

Sajid Saddiq.

Executive Summary

May 2017

Contents

1.1 Background

Text, language, pictures and icons are recognized as everyday forms of communication. Despite using these in seemingly unproblematic ways, from a social research perspective our capacity to access the meanings associated with these communications and the veracity of those meanings is not straightforward (Bartmanski 2014).

Visual Communication (VC) is one such form of daily communication. It is used extensively in organizations, and particularly in relation to shop-floor environments (Greif 1991). At this level, visual communication can be designed to enable those that are operating there to be aware and to take necessary actions in timely way. Arguably a "...a visual workplace is a self-ordering, self-explaining, self-regulating, and self-improving work environment where what is supposed to happen, happens on time, every time, because of visual devices" (Galsworth 2004, p44). It can support managers in their need to inform and manage daily activities, by providing those operating the shop-floor with a "self-service compass" (Greif 1991). This enables organisational members to orientate themselves to the needs of the organisation; these needs being defined by the managers within the bureaucratic hierarchy, but ultimately by the imperatives deriving from high investment mass production environments, i.e. stable supply of inputs (materials, labour), continuing demand for standardized output (product) (Scott 1992). However, how can we access and measure the communicative power of any given visual communication? How well have the messages been transmitted and subsequently received?

1.2 Purpose of Research

My interest in visual communication stems from having worked in manufacturing organizations for many years and encountering numerous examples of their use on the shop-floor. Within this shop-floor context, on the one side there are managers who author visual messages and on the other side there are operators, who are the intended audience. This is illustrated in Figure 8-1
Figure 8-1 Manager to Operator Communication

below, with the manager on the left using visual communication to send a message to the operator shown on the right.

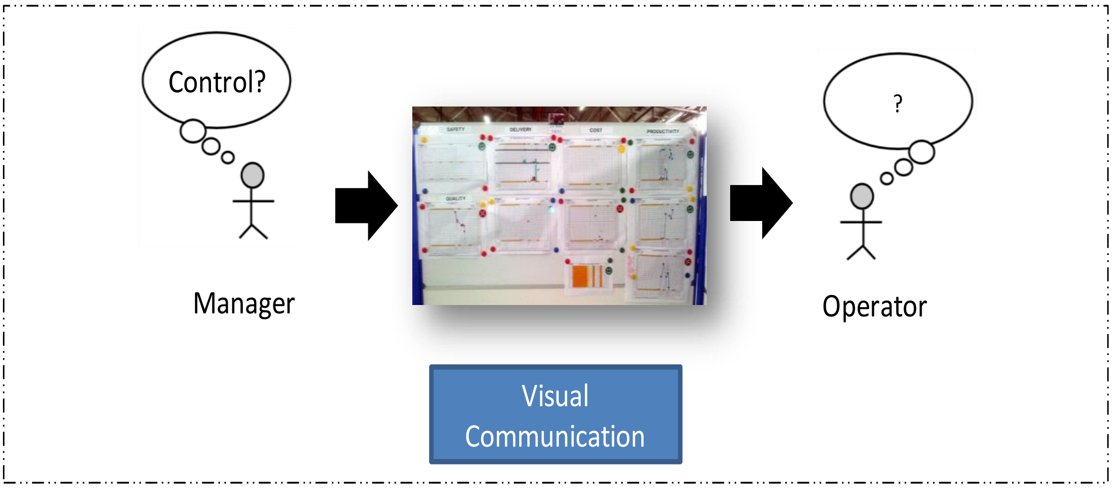


Figure 8-1 Manager to Operator Communication

My concern was that if visual communication is used, without considering the correlation between communicator and those being communicated to, then the effectiveness of that visual communication is questionable. If organisations are simply copying and pasting what has worked in the past, this does not guarantee that it will work in the future (Hamel 2009) or even that it is the right solution for now (Bresciani & Eppler 2009).

I wanted to understand from those charged with the responsibility to affect control of the shop-floor about how they consider particular visual signs, what is the intention of those signs, and to then understand from the target audience of these communications if their subsequent interpretation having encountered these signs agreed with the intended meanings. But how can this correlation be known unless it can be measured in some way? To date, due to the fragmented understanding and lack of holistic approaches to investigating visual communication, this remains a subject that is empirically under-theorised and detached from real world professionals and contexts. The aim of this research is:

- To measure the level of correlation between the intended and interpreted meaning of visual communication.

The objectives to achieve the above aim were:

- To extract (elicit) psychological constructs from managers who author the visual communication utilised on the shop-floor.
- To use these psychological constructs to create a measurement instrument to enable an exploration of the intended and interpreted meaning of visual communication.
- To conduct this research using methods which were consistent with a neo-positivist approach.

1.3 Method of Data Gathering and Analysis

This research was warranted because visual communication is used in organisations has been said to be important (Bititci et al. 2016, Jaca et al. 2014). However currently there does not seem to be a scientific way of comparing and contrasting the intended and subsequently interpreted meaning. This thesis helps to close this gap in understanding in respect of visual communication.

The overall methodology I selected to investigate this issue was a holistic single case research study using an embedded approach (Yin 2009). This embedded design enabled me to gather data about each of the six individual production areas (value streams) of the case study site. This subsequently enabled me to compare and contrast the data across and between these differentiated value streams.

I used the Shannon & Weaver (1949) Communication Model as a conceptual model, shown in Figure 8-2 below. This is consistent with the definition of communication where it is said to be a process of shaping knowledge to information by one cognitive system, the transfer through some medium and the subsequent interpretation by a second cognitive system (Lenski 2010). Clearly in the case of visual communication this medium is through the use of visual artefacts.

I structured my research steps using the Repertory Grid Analysis (George Kelly) design. This design comprised three parts, i.e

1. Elements,
2. Constructs and,
3. Evaluation.

These three steps are shown below in Figure 8-2 superimposed on the Shannon and Weaver communication model (1949).

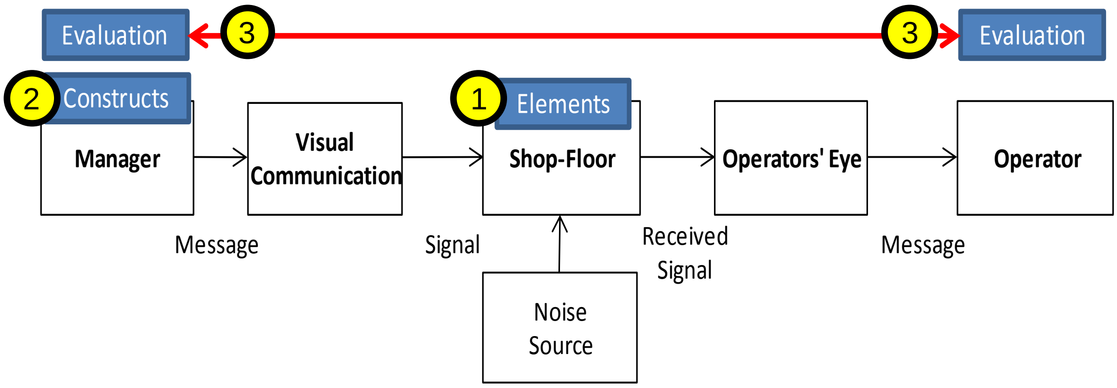


Figure 8-2 Alignment of Repertory Grid Analysis and Conceptual Model

(Based on the Shannon & Weaver (1949) Communication Model)

The **Elements** were photographs of examples of visual communication currently in use on the shop-floor. The technique used to collect this data is called participant-led-photography (Wang & Burris 1997). This involved asking managers to take photographs of a number of shop-floor visual communication from within their own production areas (value streams).

The above photographs were used as input data to the second step of the research referred to as **Constructs**. This next step was aimed to explore the psychological constructs that were 'motivating' the use of visual communication by giving the managers the opportunity to contextualise and codify the content of the photographs; exploring what manager's think are the reasons for using particular visual communication. I used a data collection technique called photo-elicitation (Botterill & Crompton 1987). The photographs collected by each manager (six managers in total) were presented back to the same manager as part of a structured interview. They were encouraged to speak about what they saw in those photographs. Classically within Repertory Grid designed research, these photographs are presented to the participants as triadic sets. The participants are asked to consider how any two photographs are similar to each other, yet different in some way from the third. The similarity between any two is intended to elicit one side of a psychological construct, and the difference between these two and the remaining third element is intended to elicit the polar opposite of that same construct. This elicitation technique results in the generation of bi-polar constructs that make them suited for the creation of a questionnaire.

An approach was necessary to take the paired constructs from the above six different photo-elicitation interviews, and to reduce the various construct statements to a combined single unified consolidated list. This was so that the unique constructs that emerged from the six interviews could be identified and operationalised in the form of a survey. A technique called ECRS (eliminate, combine, rearrange and simplify) (Training within Industry Service 1944, p3) was used as a form of self-administered content analysis. The four steps of ECRS were as follows:

> "...**ELIMINATE** unnecessary details, **COMBINE** details when practical, **REARRANGE** for better sequence and **SIMPLIFY** all necessary details..."

(Training within Industry Service 1944, p3)

The above three data collection steps resulted in revealing ten bi-polar constructs. The final step of the design is referred to as **Evaluation**. During this final phase of data collection a questionnaire was created from the consolidated constructs. A benefit of using the photo-elicitation method is the ‘dimensionality’ (**Pike** 2007) of the participant created constructs that allows them to be used to both categorise (construct-wise) and discriminate between (rating wise) the objects (visual communication) being considered. This feature of photo-elicitation, in the context of a Repertory Grid Analysis design effectively allows it to be used to create a bi-polar questionnaire

I administered this questionnaire on a one-to-one basis, according to my research design. It was administered to a total of 12 managers and 18 operators across the organisation, two managers and three operators in each of the six value streams.

In summary, participant-led-photography has enabled me to capture the real world usage of VC within its situated context, directly from the shop-floor. This method empowers those managers who use visual communication to capture images of such communications from within their own working environments. These photographs are subsequently used to elicit the psychological constructs of those managers, therefore by entrusting the selection of these photographs to the managers ensures that the key imperatives that motivate the usage of such photographs is more likely to emerge.

Photo-elicitation has enabled this research to access the meaning of these visual communications in the words of those who use them in their everyday work activity. The administration of this technique resulted in the emergence of ten unique bi-polar constructs.

Questionnaires based on the constructs were administered to a number of managers and their direct sub-ordinates. This has provided access the respective understanding of these two groups in relation to a number of images.

Overall the use of the above techniques enabled a measurement to be made. On the one side there is the meaning of signs from the perspective of those managers charged with the responsibility to affect control of the shop-floor. On the other side is the target audience, i.e. operators. These measurements allow a comparison to see if the subsequent interpretation of these signs by the operators agreed with their respective managers.

Having conducted the research I found that the methods worked well in that they were practical to apply, and the data that emerged could be shown to be statistically significant. The results revealed interesting insights into the way that different signs were more or less well understood between the two parties, and these are discussed next.

1.4 Findings

1.4.1 Psychological Constructs

The first part of this research revealed the psychological constructs the managers were using to make sense of their environment. The key findings from this elicitation activity were that the emergent constructs strongly connected to particular dominant issues associated with the operating environments, as framed by the individual managers. It showed how the differentiated value streams were focussed on different blends of imperatives that were somewhat predictable, based on imperatives such as the use of particular manufacturing technology, or deriving from the issues highlighted as being critical by the customers. Examples of the findings for the individual value streams were:

- Value stream one - the environment was characterised by small batches, requiring frequent machine changeovers, of large heavy products manufactured on relatively dated stand alone equipment. The emergent themes from this area, witnessed by the psychological constructs of the manager, were mainly focused on safety related issues.
- Value stream two - was a heavily automated production line with the role of the operators associated with monitoring the production process. Here the construct themes that emerged were connected with the product quality and product/process data collection.
- Value stream three - had relatively less automation and a greater variety of products. This particular area was being challenged because of deteriorating margins despite increasing volumes. The dominant themes that emerged were the need to schedule multiple different part numbers, and driving improvements to sustain and improve the profit margin.
- Value stream four - was of a high variety, small batch production area dominated with a large number of manual processes. This meant that a certain level of inventory was necessary to keep people gainfully occupied, but at the same time this had to be managed to keep the workplace organised. The themes that emerged here were connected

with orderliness, scheduling, and the need for feedback to the operators about the performance of the area.

- Value stream five - was a low volume high variety area with very large, dated equipment. The design of the equipment was unsuited to the smaller batch production runs now being produced. The themes that emerged were linked to the need for planning, machine set-up, quality and safety.
- Value stream six – this value stream was effectively an internal supplier, supplying the first five value streams with what they used as input raw materials for their processes. These products, with relatively short shelf-lives, required a large range of raw ingredients. This had to be scheduled and managed through often long supply chains. The key themes in this area were a focus on raw ingredients, their availability and scheduling. It was also about providing feedback to the operators about how well they were doing in supporting their customers.

The above findings are significant in their own right as well as when considered in the context of visual communication. It highlights how the managers are intimately bound within their value streams and its imperatives and how these imperatives can be quite localised. Bordering areas, often separated by a mere line painted on the floor, provide a contrasting array of imperatives.

A range of internal and/or external influences were driving the focus themes for each value stream, i.e. types of equipment, levels of automation, batch sizes, variety of products, business pressures such as profit margins, product shelf-life etc. These factors emerged in what the managers selected to photograph as well as elicited as being dominant in their areas.

The findings that different areas could behave relatively independently are consistent with the design of the organisation. Automotive UK had been differentiated to discrete production areas (value streams) with dedicated production teams. The purpose of creating these value streams was to enable the local production teams to manage and align themselves with the value stream imperatives. These findings, by the use of the above methods, confirmed that the respective needs of the value streams were different from each other and that these dominant themes from within those environments were identified by the managers.

1.4.2 Survey

A survey instrument was created using the top ten unique themes that emerged from the photo-elicitation and ECRS activity. Administering this survey to a number of managers and to the operators that directly report to them has provided some interesting insights into the use of visual communication and some best practice lessons learnt.

Ten photographs of visual communication were rated using the survey. These photographs (examples of visual communication), were selected by the managers from areas that they were responsible for. The data that emerged from the survey was analysed using exact match contingency tables.

Having analysed the results for these photographs, these were ranked from those with the highest intended versus interpreted correlation rating to the lowest rating. Overall a general pattern emerged which can be characterised as consisting three groups of effectiveness.

The first group consist of visual communication with the strongest correlations. These are the ones where the communication has been standardised across the plant; being used in several if not all value streams. Those visual communications that had a standardised site wide design, and were used regularly in accordance with organisation policy, tended towards the higher ratings of correlation. They tended to be better designed in respect of good strong titles and labelling, and also in terms of insistence by managers that they be used. For example photograph two, showing the 'shift communication board', see Figure 8-3 below scored highly in terms of rating matches. This was despite it being a complex example, with many different individual elements of communication.

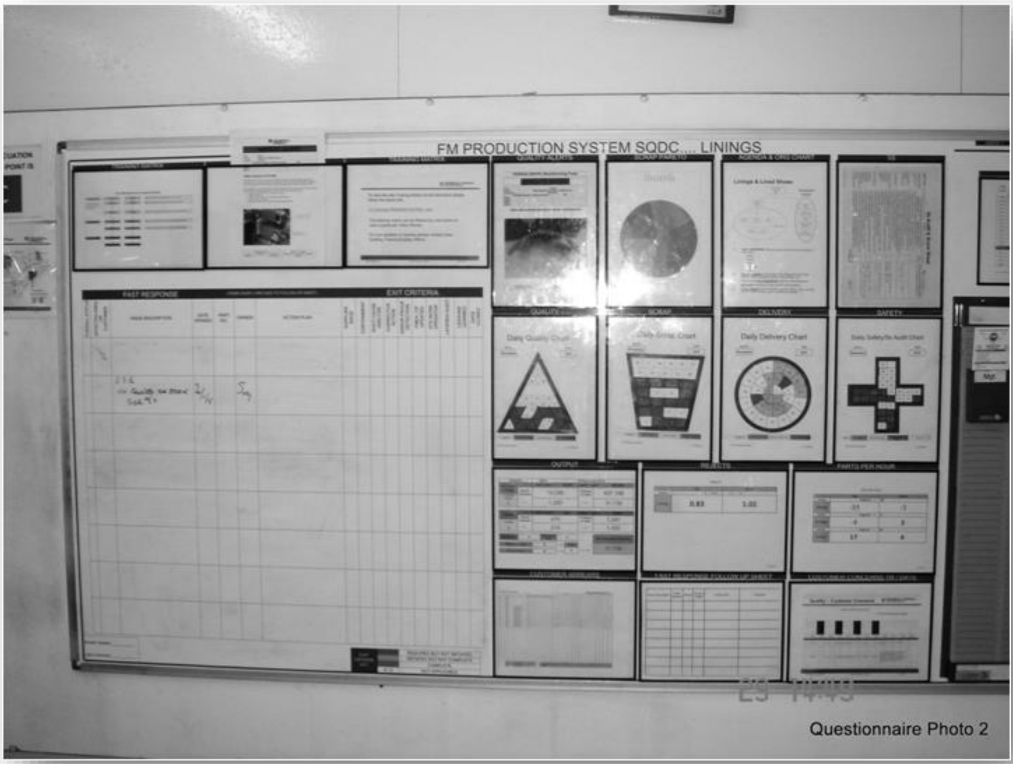


Figure 8-3 Communication Board (1st Highest – Average of 26% Rating)

The key findings indicated by this are that clear unambiguous titles as headings to the visual communication seemed to help improve the effectiveness. This was demonstrated by several examples in both a positive and a negative way, i.e. greater agreement was reached when there were clear titles about the visual communication. However, if the title was misleading, then those unfamiliar with the visual communication would take the title at face value and assume it was accurate.

Beyond the title it seemed important that labels, or other identifiers, i.e. silhouettes on the shadow boards, were also useful to identify elements of the visual communication and improve their effectiveness. Where these were missing there was more opportunity for misalignment in intended and interpreted meaning.

The usage of visual communication within the value streams often seemed reliant on contextual knowledge by the managers and operators to make up for shortfalls in their visual design. It seemed that generally less care was taken for internal visual communication than those that were expected to be shared with outsiders to the value stream. It may be that the social context can bridge the gap in poor design in this particular type of environment because of its slow to change character with overall relatively few key imperatives, but this may become dysfunctional in alternative, more dynamic environments. The key learning point was that to positively affect the effectiveness it was important to have well designed visual communication, which was well implemented, through good choice of location and training, followed by clear enforced policies about how they were to be used.

The second group consisted of communication that had the weakest rating. These were typically being used only within individual value streams. These can be contrasted with the group mentioned above, in that the very features that made that a strongly communicative visual communication, were missing in this group. They were often designed informally, and were not as well managed from a visual communication perspective in terms of clear titles, labelling, training, or insistence in their use. Photograph nine, showing a tooling shadow board (Figure 8-4 below) had the lowest rating of any of the photographs.

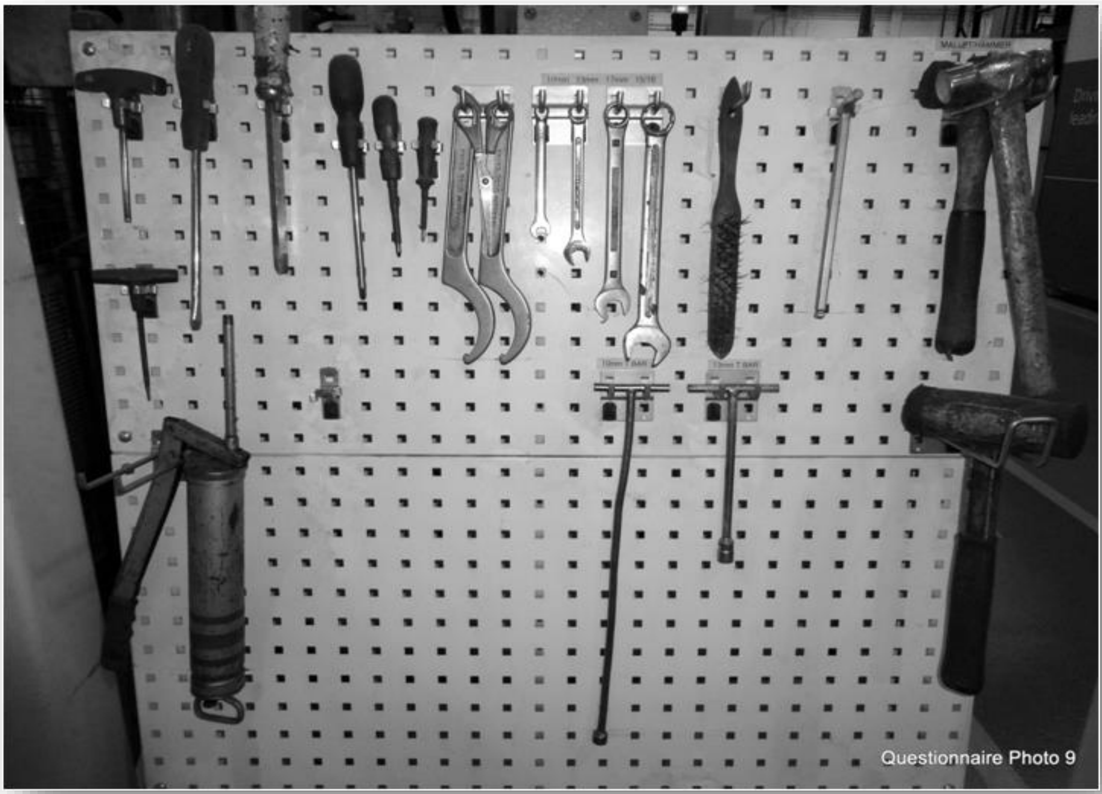


Figure 8-4 Tooling Shadow Board (10th Highest – Average of 7% Rating)

The third group consisted of those that had a somewhere in-between rating of the other two groups. These visual communications were both from across and within value streams. These tended to suffer from some strengths and some weakness from the visual communication at either end of the scale. In this group the labelling was somewhat ambiguous or missing, causing the communication to sometimes be incorrectly identified. This misinterpretation was typically by those that were from outside the particular value stream where these communications were situated, so were unaware of its usage context. Photographs Nos 6 shown below in Figure 8-5 is an example of a visual communication that can be considered part of this third group.

Figure 8-5 Quality Standards Board (5th Highest – Average of 11% Rating)

1.4.3 Issues Emerging from Literature

The above findings have also contributed to some of the issues that have emerged from the literature, i.e. issues such as organisational control and value stream imperatives. I will discuss each of these in turn, relating them to the respective literature.

Organisational Control - To help contextualise this discussion I have used the cybernetic systems model (Scott 1992) shown below in Figure 8-6 below. I have superimposed the three types of control used in organisation, i.e. bureaucratic (B), output (O) and cultural (C) (McAuley et. al 2014) to this diagram. The results from this study and the implications to organisations can be described with reference to different parts of this diagram.

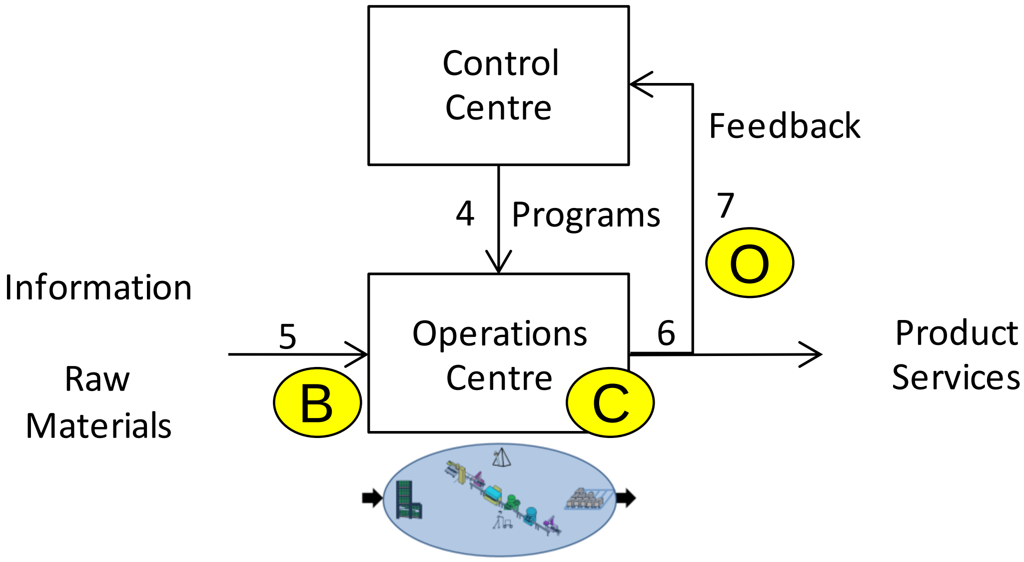


Figure 8-6 Modified Model of Cybernetic System

(Scott 1992, p81, adapted from model by Swinth)

The results have shown that the focus of the visual communication can be seen to be related directly to operational control issues. The focus is on men, machines, and materials. The purpose is to ensure that planned output is maintained whilst keeping the operators safe and productive. In this respect the findings are consistent with the cybernetic model presented above (Figure 8-6). The visual communication themes point to controls related to the process, shown as the operations centre, its inputs, indicated by arrow number four and five, and outputs, indicated by arrow number six and seven. The photo-elicitation highlighted the managers' motivation for using visual communication as comprising mainly bureaucratic (B) and output (O) forms of control. The output forms were related to monitoring the outputs and taking action based on their analysis. An example of this seen in the research was the use of production tracking boards.

Organisational Imperatives - The nature of mass production organisations is said to impose certain operational imperatives (Schmidt 2005, Thompson 2004). These imperatives are central to the trade-off decisions that have to be made by mass-production organisations to profitably run their operations (Schmidt 2005). The operations management triangle (Schmidt 2005) asserts that there are three such imperatives and there is a need to constantly seek balance between them; to balance the substitutability between inventory, demand information and available capacity. Schmidt (2005, p93) states that "...a higher level of capacity can substitute for relatively lower levels of inventory and information, a higher level of inventory can substitute for relatively lower levels of capacity and information, and a higher level of information can substitute for relatively lower levels of capacity and inventory". It is relevant to reflect in this section on the findings for an organisation that fits the definition of mass production (Thompson 2004), to see what is informing the themes elicited by those working at its ‘technical core’ (Thompson 2004), i.e. shop-floor, and to understand the role that visual communication is playing

The information flows shown by the arrows numbered four, five, six and seven above, highlight critical communication that enable the organisation to function. In this research there were examples of visual communication that were selected by the managers that represented these different information flows. However, an important point is that a simple analysis of the technology, characterised generically as mass production, or only looking at the layout, may be insufficient when considering the role that visual communication has to play. To an observer, the layout of all six areas could look very similar, but the term “technology” in its broader sense is useful to elaborate. Perrow (1967) describes technology as the "work done in organisations…that is, organisations are seen primarily as systems for getting work done, for applying techniques to the problem of altering raw materials - whether the materials be people, symbols or things" (Perrow 1967, p195). If an effective end-to-end, intended-received-interpreted, visual communication system is to be created to support, for example, a performance management system, it is necessary to recognise the vertical differentiation of the shop-floor itself into discrete value streams and not to treat it as a single organisational department. This is effectively to recognise that the shop-floor is not a single socio-cultural entity (Seppanen & Valiverronen 2003), but has been designed into discrete value streams. These correspondingly affect discrete socio-cultural sub-environments, and set the context for the needs of visual communication.

Perrow (1967) alludes to the issues created by shop-floor differentiation in stating that he views technology as an independent variable, and that the "...arrangement amongst people for getting this work done as a dependant variable" (Perrow 1967, p195). Arguably this supports the view that visual communication, as an arrangement amongst people for communication, is contingent on technological choices. The shop-floor has been differentiated in terms of different manufacturing technology, to create different value streams. Furthermore, it has been socially differentiated into teams of individuals focussed on discrete areas and customers. This informs us that the use of visual communication cannot be uniform in each area. It is likely that different value streams, as different socio-cultural environments, may need to use visual communication to focus on issues specifically important to them; generic and unique imperatives of the environment and sub-environments within which it is being used. It is by understanding the value stream imperatives and uniquely blending the use of visual communication that could then contribute to a coherent communication system.

In summary, in this section I have discussed the important context of visual communication in the management of the shop-floor. In this study, by engaging the managers at Automotive UK and understanding the issues that they were focussed on, this research has revealed some interesting and generalisable findings. The first of these are the generic topics (themes) that were motivating the need for the communication, and I have described these as the organisational imperatives. The second was to look at how control was being affected, in the context of these themes, through the use of visual communication.

By identifying the role that visual communication plays in the organisation, and its importance for regulation, highlights the importance of enabling access to the intended and interpreted meaning of visual communication.

1.5 Summary

The aim of this research study was to explore the intended and perceived meaning of visual communication found in organisations, specifically those used in shop-floor contexts. In doing so the intention was to generate new insights into the concepts and use of visual communication.

In organisations, visual communication is said to contribute to and sustain continuous improvement (Jaca et al. 2015), but how can this be known unless it can be measured. Due to the current fragmented understanding of this topic and lack of holistic approaches for investigation, this is a empirically under-theorised subject, somewhat remote from the real world professionals that could take some benefit from such methods.

To access the intended and perceived meaning, the Shannon & Weaver (1949) Communication model has provided the necessary conceptual framework. Although originally created to depict telegraphic communication, it is said to be representative of all forms of communication and was used successfully to theoretically underpin this research. This structure, through a neo-positivist case study design, has enabled the exploration of visual communication in a manufacturing environment. Using a number of qualitative and quantitative data collection methods, based on the Repertory Grid Analysis design (George Kelly), enabled the themes that were motivating visual communication to be operationalised. These methods have put at centre stage the motivation of those involved in the acts of visual communication by empowering their voices. This has been done whilst retaining a strong focus throughout on practice based issues to ensure the utility in future for researchers and managers to make sense of the usefulness of real world visual communication.

This research has demonstrated how individual managers are bound by the overall imperatives for mass production environments, using visual communication to affect control of issues such as capacity, inventory and customer demand. However, what has also been demonstrated is their further orientation towards specific requirements based on the contingency of their sub-environments, i.e. safety, profitability, supply chain issues, etc.

The findings of this thesis, in relation to enabling the measurement of visual communication meaning within its situated context, contributes to both organisational and management theory. The ability to measure what individuals interpret from different visual communication in comparison to the intended meaning, is a first step to focusing a scientific light on its use and usefulness. Doing this using a direct form of analysis for evaluation, without recourse to specialist statistical analysis, also lends itself to being practised by managers in the future.

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8.20 Appendix T – Dissemination – Industry Leaders

I have included an example of where I was given the opportunity to present to a group of industry executives. This was a dinner and certificate presentation evening for delegates who had completed their six sigma certification. Present at the evening were managers from a number of automotive and manufacturing organisations such as Action, Anopol, Brose, Capella, Gestamp, Jaguar Land Rover, KPIT, Maier, Multimatic, Radshape Sheet Metal, Stadco, Toyota, WHS Plastics, Valeo and ZF Lemforder. The slides used for this presentation are shown below.

Visual Communication Presentation – Six Sigma Certification - Capella Awards Evening

Following: Presentation (see attached) delivered during awards ceremony organised by Capella Associates Ltd.; for Six Sigma Green and Black Belts certification

Date: 8th Dec 2016, Location: Coventry

Capella
making good people great

Companies present:
Action, Anopol, Brose, Capella, Federal Mogul, Gestamp, Jaguar Land Rover, KPIT, Maier, Multimatic, Radshape Sheet Metal, Stadco, Toyota, WHS Plastics, Valeo and ZF Lemforder.

Total Number of attendees: 72

Operations Excellence Group / Braking | Data classification: External | 8/12/2016 | 1

Problem Solving – Context in Organizations

Policy Deployment

- The objectives.

Mission – Customer Focus.

Management Systems

- What is the target?
- Where are we now?
- What are the problems?
- What are we doing about them?

Management

- Clearly define and cascade the objectives.
- Craft the organisational hierarchy and communication.
- Green Belt's - Enable knowledge, skills and behaviours (crucially problem solving).

Green Belts

- Skills and confidence in problem solving – leading to process improvements.
- Team Based.
- Using tools – establishing the business needs.
- Structured approach - helps to monitor your own progress – and avoid jumping to solution mode.

BITITCI, U. S., Carrie, A. S., & McDEVITT, L. (1997). Integrated Performance Measurement Systems: A Development Guide. International Journal of Operations & Production Management, 17(5), 522-534.

Visual Communication – Relevance to Six Sigma

Clarify the Problem / Breakdown the Problem / Set a Target / Analyse Root Causes / Counter-measures / Evaluate Results and Processes / Standardise Successful Processes.

Problem Statements
Operational definitions
SIPOC
CTS Tree
Graphical Analysis Tools:
- Tally chart
- Run Chart
- Histograms
- Box Plots
- Scatter Plots

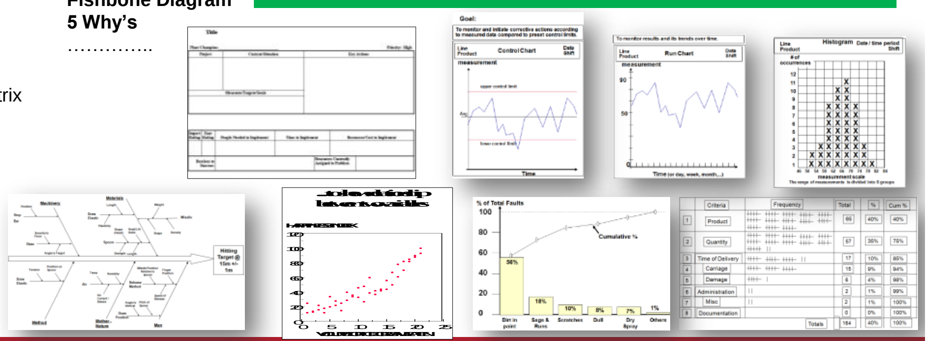
IS/IS Not
P-Diagram
Cause and Effect Matrix
Data Variation
Data Collection Plan
MSA
Process Capability
Normality Testing
Hypothesis Testing
Regression Analysis
ANOVA

DOE
Benchmarking
Affinity Diagrams
Pay-Off Matrix
Process Mapping
Charters!
Brainstorming
Pareto Chart
Fishbone Diagram
5 Why's
…………..

Green Belts

Diagnostic Tools

- Gained knowledge about a lot of tools.
- How to use them.
- When to use them to support problem solving.
- Used to get to the root cause.
- Many are quite visual – helping you to grasp the key point quickly.



Visual Communication – To affect Control

Control Plans
Control Charts
SOPS and Audits
Error Proofing
Visual Controls

Green Belts
- As green belts always consider how you affect control of improvement back into the workplace.
- Technical fixes – physical changes.
- Also consider using visual tools to embed your new found knowledge.

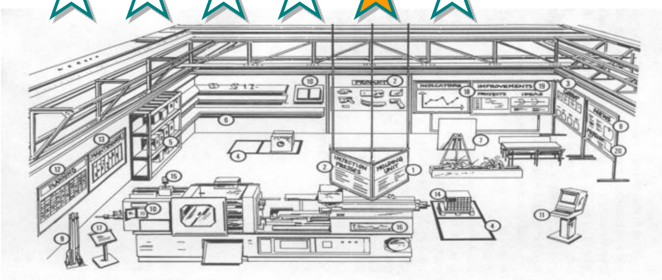
Control Tools

- In a visual organization, it is possible to understand the **flow** and **status** of activities quickly and simply through observation (without receiving verbal indications).
- This situation promotes self-management - avoiding the need for micro-supervision of the operator enables easier management.
- It is about **CONTROL** built into the fabric of the work environment.

- Enables easier abnormalities detection.
- Helps those in the workplace to understand quickly the new right way to do things (what you have learnt).
- Visualisation is achieved by using a range of methods, i.e.:
  - visual aids on the process,
  - visual scheduling and stock management,
  - visual documents (SOPs), etc…
  - using limits, colours, alerts, etc…

MCAULEY, John, JOHNSON, Philip, DUBERLEY, Joanne. (2014). Organization Theory: Challenges and Perspectives. Harlow, Pearson. (Electronic edition).

Visual Communication – ELEMENTS of Visual Communication



Green Belts
- Not an exhaustive list – but not bad.
- Can at a glance management be achieved – within 1 second can see if it is OK/NOK.
- Think about change of personnel – would your controls still be in place?
- If your controls malfunction – would this be highlighted?

Team Territory:
1. Identification of territory
2. Identification of activities, resources, and products
3. Identification of the team
4. Markings on the floor
5. Marking of tools and
6. racks
7. Technical area (Autonomous Maintenance)
8. Communication area and rest area
9. Information and Instructions
10. Neatness (broom)

Visual Documentation:
10. Manufacturing instructions and technical procedures

Visual Production Control:
11. Computer Terminal
12. Productions Schedule
13. Maintenance Schedule
14. Identification of inventories and work-in-process.

Visual Quality Control:
15. Monitoring signals for machines
16. Statistical process control (SPC)
17. Record of problems

Displaying Indicators:
18. Objectives, results, and differences

Rendering Progress Visible:
19. Improvement activities
20. Company project and mission statement

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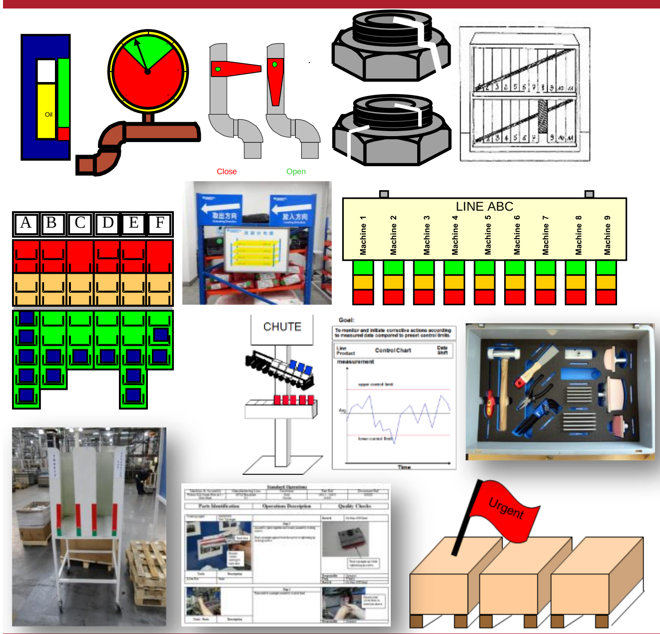
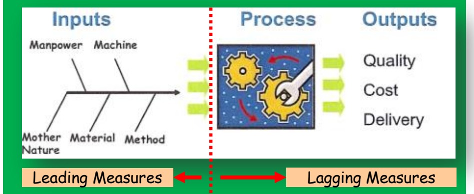
Visual Communication – Examples of VC for Control



Green Belts



Leading indicators monitor whether the tasks being performed will lead to the expected output and,
Lagging indicators monitor the outputs that have been achieved.

- Enables time and place separation between sender and receiver.
- Self-service.
- Use of artefacts.

Congratulations

Well done on your Certification !

Use and share your new knowledge and skills.

Support others.

If you have questions please see me?