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Decision Making in Engineering Organizations: A Soft Action Research

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Abstract

A predominant approach for organisational inquiry is Action Research, but it comes in many forms and in some cases ends up as all research and no action or vice versa. A prevalent feature of all action research is the importance of meeting stakeholders in order to gain an understanding 'from within'; This is specifically the case where Soft Action Research is the basis of the inquiry.

In this paper, the author reflects, briefly, upon the history of action research and the lessons learnt from the outcomes of a recent research he conducted using the Appreciative Inquiry Method (AIM). The author discusses the adoption of soft action research to investigate the domain of decision-making in complex engineering organizations in a bid for technical managers to learn about their own decision-making practices and optimise their decisions. The main study findings conducted across 2 different agencies were largely consistent and they include the following: superior officer's view/opinion, technical know-how and integration with other departments are the most important to the technical managers when making their decisions. Within the concept of power-play in decision-making making - the superior officer's influence was found to play a key role in addressing varying judgements or split opinions due to their experience, and also in getting management's support on their critical decisions.

The lessons learnt from the researcher's experiences will help inform other researchers and professionals using the Soft Systems Method of inquiry and open opportunities for others to explore further the merits and demerits of Soft Action Research.

The method discussed in this paper can be used to acquire quality data which can be used to develop training prompts for artificial intelligence applications and help develop a repository for multi-criteria decision analysis and algorithm/method for analysis of enterprise risk. The overall research is part of the organization's management (CSTP-NASRDA) plan to improve decision-making amongst its technical managers.

Keywords: Appreciative Inquiry Method (AIM); Appreciation; Decision-making; Intuition; power-play

Introduction

To optimise complex decision making in technical organizations, and to develop an understanding of the relevant stakeholders/decision-makers as gained from previous experiences. It is informed by the decision-making domain of technical managers in the Space Agency (NASRDA) as an example, and lessons identified from the process are reflected upon.

The research discussed in this paper had arisen from a critical evaluation of the literature by the author who concluded that from the studies conducted it was found that the rule-based and logical elements of the expertise could be modelled but that the more tacit, intuition-based elements of the expertise, which constitutes the engineering and professional judgement of the technical managers, could not be easily modelled. The research focused upon the experiences of the technical managers in order to gain an appreciation of how they make their decisions. This aspect of the study was to be undertaken by adopting a method of soft action research. Soft action research involves 'finding out from within' which necessitates interaction between participants.

The purpose of this paper can be subsumed into three parts:

- To explore the historical literature on organizational inquiry using a systems thinking approach
- To discuss the organizational inquiry into the domain of decision-making in the Nigerian Space Industry using Soft Action Research as a soft system approach.
- To describe the method of soft Action Research - AIM, and how it was used to gain understanding from the technical managers.
- To reflect upon lessons learnt from the creation of an Action Research environment.

The paper is arranged as follows: first, the area of interest and the outcome of a critical review of the literature; second, the method chosen, the outcome of the study and the lessons learnt.

Organisational Inquiry and Action Research

Carrying out organisational investigations or inquiries has always been difficult and what is considered as Action Research now appears to come under many guises or flavours, consequently, its original concept (Lewin, 1948)[1], has produced several interpretations. Lewin (1948)[1], suggested that a situation or better still a problem domain should be considered as a 'whole', and those that make it up are not just influenced by the situation itself but by different life experiences. These organizational inquiries have resulted in valuable insights into organizations. Valuable insights and useful accounts of the subsequent and continuous development of these ideas across disciplines were provided by Reason and Bradbury (2008, pp.77-92)[2].

The development of Action Research can be grouped into different sections, from the Socio-Technical perspective of the Tavistock Institution, community building and Somatic development and organizational development. Reason and Bradbury (2013)[3] provided many examples of theory and practice of Action Research but it does not acknowledge the contribution of Vickers's notion of Appreciative systems. Checkland (1999, pp.141-146)[4] for example discussed both the 30-year pioneering work at the University of Lancaster regarding the Action Research programme and the immense contribution of Vickers's notion of Appreciation. The term Action research is fundamentally attributed to Lewin (1948) (Vickers, 1983(b), p.67 & c.4)[5]. While Reason and Bradbury (2013) contribute to the literature on Action Research, not all approaches(flavours) of Action Research are covered. The author considers this observation important because Action Research will be directly influenced by the inquirer/researcher's perception; Organisational inquiry is dependent upon the idea of 'organisation' as perceived by the inquirer or researcher.

From the literature (Reason & Bradbury, 2013; Bradbury, 2008)[3], there are different philosophical paradigms underpinning Action research, but these paradigms are difficult to capture within a coherent group. Hussey and Collis (2003)[6] provided useful context from which one can think about Action Research. Three paradigms of Action Research were suggested, although the author is of the view that these classification does not provide a generic framework of approaches which is universally agreed. The first one is 'classical action research', also known as the 'positivist approach to action research' that perceives research as a social experiment; It describes action research as a method to test the hypothesis in the real world (Stowell & Kramarova, 2023, pp. 3-5)[7]. The second one is 'contemporary action research' also known as 'interpretative approach to action research' which perceives business reality as socially constructed and focuses on specific organisational and local factors when conducting action research. The third one is referred to as 'critical action research' which adopts a critical approach towards business aims and processes for improvements. To this list, Stowell & Kramarova (2023, pp. 3-5)[7], added soft systems thinking and practice (Checkland, 1999)[4]. In soft systems thinking and

practice each situation makes use of 'Epoché' (suspension of judgement); it is approached without regard nor recourse to previous experience. The research is undertaken by the researcher becoming a part of the problem domain or situation of interest. At the heart of soft systems thinking and practice is the generation of a cycle of learning through which the stakeholders and participants can develop actions for change. It is to the latter the author now turns.

The author adopts soft systems thinking and practice as the method of choice for inquiry. The method is agnostic to the situation of interest of problem domain (M) and it has a synergistic relationship with the framework of ideas (F). The stakeholders participation is at the heart of soft systems thinking and action research (Flood, 2010, p.270-284)[8]. Key criterion for soft action research is recoverability. The research activity should be made explicit in order for external party to be able to have a trail of the whole process (Checkland & Holwell, 1998, pp.9-11)[9].

A method of soft action research was considered because it would enable the researchers to gain an appreciation of the experiences of local citizens in gaining access to (FFV).

Organizational inquiry, the idea of Soft Action research and the notion of an Appreciative System

Within the overarching idea of systems thinking is Soft systems which is underpinned by the phenomenology of Husserl and the Sociology of Schutz (Stowell & Kramarova, 2022, p.4)[7]. This idea of soft systems were combined with the experience of academics and practitioners such as Vickers 1983[5] and Ackof 1977[10] and led to the development of a new way of thinking about systems and of 'organisational' (see Checkland 1999)[4]. The notion of 'system' reflected an acceptance of the unpredictability of what is perceived, but shaped by experience. The author describes such a system as a particular phenomenon formed from a priori forms of experience and not posterior deduced from experiments. With this in mind, Stowell (in Stowell & Kramarova, 2023, pp.4-6)[7] describes the notion of 'system' as that which is anchored to the idea of holism, and that any 'phenomenon' we perceive is one selected from 'something else' that may exist in a physical sense but also possess a sensory existence which appears to different to observers in different ways.

'Systemic' thinking helps to gain a greater understanding of the 'system' of interest which can also be referred to as problem domain; thinking about something as a System in this way gives 'shape' to the phenomenon with which we are concerned (Stowell & Kramarova, 2023)[7]; This is a fundamental description of Soft Action Research. it is a way to help the inquirer or researcher gain appreciation(understanding) of the situation of interest (problem domain) in its entirety.

With Soft action Research, the inquirer becomes part of the inquiry and submerged in the situation; Checkland and Holwell (1998, p.14)[9] discussed one of the issues with action research is that it can degenerate into all action and little or no research, and it is difficult to see the findings or outcome as any more than being anecdotal. Stowell (in Stowell & Kramarova, 2022, p.4)[7] suggested that Soft Action Research should have a degree of structure that does not necessarily constraint the participants; And that a method of organizational inquiry employed by Soft Action Research should act as a guide but not to be established as a set of rules to be followed. The researcher or observer should attempt to 'detach' themselves from past experiences and be aware of their own role and their relationship with the participants. In Soft System Methodology, this is addressed in detail through the analysis of Checkland and Poulter (2006, pp.27-38)[11].

The author of this paper supports the importance and acceptability of the idea of 'subjectivity' both for research purpose and in practice. Within Soft System Methodology is a different interpretation of the idea of Worldview also known as Weltanschauung which Checkland says '…is the most important concept in understanding the complexity of human problem domains or situations, and indeed, the nature and form of Soft System Methodology (SSM) (Checkland, 1985)[12].

The implication of this is that Soft System Research accepts a world view based upon the subjective experience of the individuals involved. The meaning each individual attach to something or to an event is created from the social setting or culture in which it exists and specifically, the language they use to explain this is abstract. Each situation individuals encounter is 'shaped' by the way they per-

ceive the world. This, in many respects, is encapsulated in Vickers notion of the 'Appreciative System', which he describes as a unique interpretive lens that provides one amongst several ways of interpreting our experience (Vickers 1983, p.69)[5].

It is a difficult task to simultaneously inquire and also accept the subjectivity of our experiences as individuals. The author believes that the method of inquiry can affect or shape the outcome, and even the selection of the 'tools' to be used can themselves have meaning for the inquirer.

In conclusion, Checkland idea of the FMA approach to inquiry offers a way of reflecting upon the coherence of the inquiry. FMA in practice is as follows;

'F' Framework of ideas: It is important for the inquirer know where they stand in the 'intellectual universe'?

'M' Method adopted: An understanding of the method of inquiry is important. M and F should have a synergistic discernible relationship.

'A' Area of Interest: It is important to note the boundary within which the inquiry is limited by The framework of ideas (F).

This involves the exploration of the decision-making process in a complex engineering/technical organization; It aims to capture the role and extent of intuition in decision making and also take into consideration the subjective nature of the factors that affect the process of decision-making while paying attention to the role of power-play/relation. This is conceptualised and viewed through the author's philosophical lens of interpretivism.

Area of Interest

The nature of this research centres around improving decision-making in complex engineering organizations. From the literature, there is a plethora of work on decision-making using varying deterministic (mathematical) approaches to develop useful models aimed at technical organizations. There were fewer works that conceived decision-making as a human activity. The fact that decisions are ultimately made by humans is often neglected, instead, humans are often treated as rational beings and decisions as an asset. The process of decision-making is also conceived as a step-wise process instead of a cycle of learning. My approach to decision making is to examine the literature on decision-making through the lens of human applications to engineering/technical organisational decision-making.

Decisions are ultimately made by humans and relevant models which are designed to guide this model must take into account the complexities involved in human decision-making process. While a lot of the existing models reviewed provided a justifiable ground for usefulness, there are a gap in the area of variability of judgements during collaborative work, how to address the dichotomy between routine and critical decisions, and the role played by human intuition. The models also are limited in terms of their ability to deal with the interplay between experience and authority; the power-play involved in decision making process in an organization.

Selected Organization

The selected organization is known as the Centre for Space Transport and Propulsion (CSTP), one of the activity centres of the National Space Research and Development Agency (NASRDA) of NASRDA in Nigeria, West Africa. To put it in context, the National Space Research and Development Agency (NASRDA) is the research and development branch of the Nigerian Space Industry (NASRDA, 2023). Another notable organization in the space industry is the Nigerian Communications Satellite Ltd (NIGCOMSAT LTD, 2023) which was once a department within NASRDA but later became an independent body. There is also the Defence Space Administration which has also gained an independent identity away from NASRDA into an independent body. NASRDA is charged with delivering the Nigerian satellite to orbit and is mandated to develop space science applications and technology for the socio-economic benefit of the nation. CSTP however, is the Centre where research to build transport vehicles(rockets) for space, defence and other scientific exploration is being carried out.

Description of AIM as the chosen Soft Action Research by the author

AIM is conducted in three or four phases, depending on the logistics of group participation (Stowell & Welch, 2012, p.52)[13] (See Figure 1). In all phases, the overall aim of the method is to enable participants to discuss the situation of interest freely and arrive at a shared Appreciation of it. The discussion is facilitated by system maps and diagrams prepared by the researcher, which the participants review, "authenticate", and use as the basis for further discussion. Throughout the enquiry, the participants' comments constitute a "Socratic dialectic" (Stowell, 2013, p.19)[14] about their judgements, which will eventually lead to an Appreciation of each other's perspectives. Group dynamics and power relations between the participants start to become evident at this stage, and the researcher may also use to reflect on the enquiry.

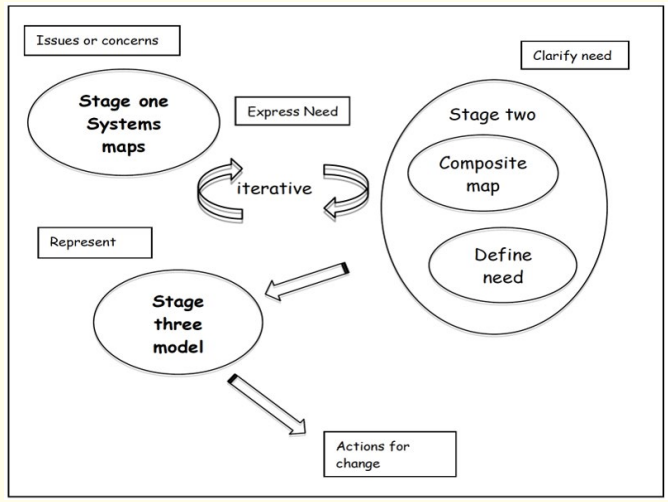

Figure 1: Appreciative Inquiry Method (Stowell, in Stowell & Welch, 2012, p.56).

From previous works using AIM (Hart, 2013[15]; Smith, 2001[16]; Kila, 2023[40]; Stansfield, 1993[17]; West, 1995[18]), the approach is made up of three phases which are related to each planned meeting with the participants rather than a particular decision of the task. It should be noted that AIM does not have to be used in this specific structured manner.

Phase one involves the development of individual systems maps and a composite map from the individual systems maps. The system maps are aggregated by the researcher into a composite system map, which is presented to the participants for authentication. In discussing the composite map, participants and the researcher continue to develop their individual Appreciation of the issue. The agreement is not always possible, but the aim is to reach accommodation about important areas and terms used.

Phase two involves the translation of various elements in the composite map into carefully described activities.

The descriptions are of some purposeful activities that are identified by considering the transformations brought about by the corresponding map elements. During this movement from map elements to systems descriptions, the researcher asks the participants questions which have been developed from the 'CATWOE' elements.

SSM (Checkland, 1981[19]; Checkland and Scholes, 1990[20]). After that, the researcher uses this information to develop a careful description of the 'system' identified in the form of a root definition (RD). A conceptual model or activity model is then developed from the root definition (RD).

In the third phase, the researcher is checking the validity of the activity model in representing the participants' view of it and to further the learning curve by using the activity model as an agenda for discussion with the participants. The outcome of checking the activity model may involve a repeated process to either re-explore the participants' understanding of the domain or correct misunderstanding of the participants' perceptions. Notably, any part of the phase may be used at any time. The figure 2 below shows an overview of the different phases of AIM and their interrelationship.

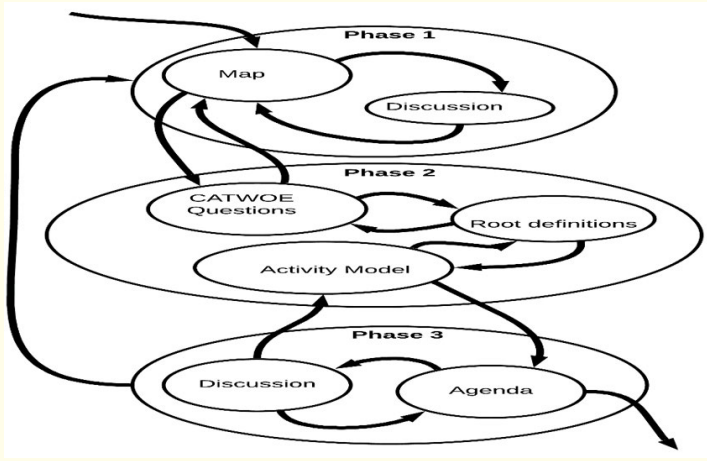

Figure 2: Phases of AIM and their interrelationship (Source: West, 1995).

The process in an AIM study is facilitated by the researcher, and then the outcomes recorded, by the tools. In the following section, each phase of AIM and the tool associated with it is discussed.

Phase 1 - AIM: Systems Maps

This is the first stage of AIM which involves the development of systems maps by the participants.

Elements relevant to the core subject are recorded diagrammatically in the form of a system map. The production of a system map allows the participant(in this case technical managers) to work on this representation alone without interference from the researcher or inquirer since there are no rules to the process other than the limitation of the form of the map itself. At the end of the first session the map offers a full, but the relatively low-level, view of the participant's thoughts about the defined situation of concern while the researcher and the experts/participants have started the 'learning" process.

The main aim at this stage is for the expert/participant (technical managers) to 'teach' the researcher about the domain (their decision-making practice) by describing the map elements while checking for any similarities or repetitions that might merit the merging of elements (West, 1995)[18]. It is useful to identify any unnecessary elements, and their meaning, that the technical managers (Participants) might have used and to verify that the elements in the maps represent activities at the same level of resolution. If they are not at the same level of resolution, it may be useful to group the more detailed elements under another heading or improve the drawing of the map so that all of the elements are considered at the same level of detail.

As an addendum to the researcher being taught about the situation of concern(decision-making practice), the drawing of a systems map is an opportunity for the technical managers (participants) to learn about their own perception and understanding of it.

Moving forward, the systems maps are then used as a method of gathering and sharing ideas among the participants (technical managers) as the systems maps are then used to produce a composite map. The composite map would include all of the different elements named, and where appropriate related or similar elements are grouped under one heading. The composite map is taken back to the individual participants and used to help improve their thinking about the situation of concern. This helps the researcher to gain an appreciation of the situation and is used as a vehicle for discussion for the next phase of AIM. This is referred to as 'shared appreciation of the situation of concern between the researcher and the participants.

Phase 2 - AIM: CATWOE/Root Definitions/Activity Models

This is the second stage of AIM where the composite map developed in stage one is taken back to the participants to improve their shared appreciation of the situation of concern by re-enforcing what elements are most important to the participants. The composite map could be regrouped into sub-maps to show elements of it.

The idea of CATWOE (Smyth & Checkland, 1976)[21] is to try to get at the central 'T' to the map elements. The aim is to try and cluster ideas and to investigate the link between them to find out what makes them `clustered' in the first place.

The researcher asks a six-point checklist for root definition development, represented by the mnemonic CATWOE, to the participants about each identified sub-map in their maps.

The key requirement of this phase is for the researcher to establish the `transformation" (T) that the map element represents. Smyth & Checkland (1976)[21] developed the notion of CATWOE as a way of testing a root definition for completeness. The elements CATWOE:

"Do not tell you if the root definition is good in the sense of useful, they do tell you if the root definition is good in the sense of well-formulated" (Wilson, 1984, p 45)[22].

CATWOE is used in AIM to ensure that enough information is provided in order to construct a description of some purposeful activity (West, 1995)[18]. This purposeful activity is then considered modellable as a system using the notion of human activity systems.

The use of CATWOE in this way allows the researcher to explore the activity implicit in the sub-map without asking context-dependent questions. The questions used are designed to supply the information necessary to describe any purposeful human activity and neither presuppose a given answer nor depend upon the researcher's understanding of the situation of concern.

A root definition(RD) is then developed by the researcher from the elements of CATWOE that relates to the sub-map from the answers to the CATWOE questions. The researcher's production of an RD is their interpretation of what has been written and said.

Phase 3 - AIM: Agendas

In this stage, the different activities defined in the activity model are used as an agenda for discussion between the researcher and the participants. This activity acts as a means of allowing them (the participants) to own revelations about the subjective area and improve the shared appreciation further. It is stressed that the activity model is not a prescription of what should happen, but is hopefully a logical model according to the understanding and appreciation of the researcher. In general, an activity model consists of an interconnected set of `what's' at the particular resolution level to be used for comparison (Wilson, 1984)[22]. The researcher asks the participants about each activity in the activity model in turn, in order to determine if it takes place in reality. The researcher determines from the participant if the `what' takes place and if it does take place then the researcher must determine `how' it takes place. If the activity does not take place the participants may be able to say why and then say what happens in reality. As the shared appreciation improves it is possible to start linking the activities together to provide a wider view. Even at this stage, new areas may need to be explored and the appropriate phase of the method can be used to facilitate this.

Using AIM as a Soft action Research in a technical organization to investigate technical manager's decision-making

Decision-making is a process of problem-solving that aims to remove barriers to achieving organisational or individual goals (Guo, 2020, p119)[23]; it is influenced by different interconnecting factors, including the use of information technology, set goals of the organization, the will and the purpose of the individuals involved. The challenges of identifying ways to improve decision-making in an engineering/technical organization are both technical and social in nature (Mumford, 2006, p.317-320)[24].

A previous review of the literature (Seyman et.al., 2021[25]; Mahmoudi & Pingle, 2018[26]; Ilori & Irefin, 1997[27]; March & Weissinger-Baylon, 1986[28]; etc.) showed there was a plethora of work on decision-making using varying deterministic (mathematical) approaches and a dearth of interpretivist research. Most of the literature takes a deterministic (mathematical approach) approach to addressing decision-making, treating humans as rational beings and decisions as an asset. Mohsen, et.al (2020, p.6) adopted a hybrid method of Multi-Criteria Decision-Making and Analytical Hierarchical Process (AHP) in a study to rank power supply systems by a government organization. Seyman et.al., (2021, p.211[25]) also adopted the Multi-Criteria Decision-Making Method (MCDM) for the evaluation and selection of relevant equipment for corresponding athletes. With these methods, drawback such as being stuck in 'local optimum' (either minimal or maximal objective solutions) was identified (Tezer et.al, 2017)[29]. It appeared that assumptions were being made about how decisions should be treated, without necessarily engaging the perspectives of those individuals actively involved in it.

NASA's Challenger disaster is an example, where it was first thought to be an error in the O-ring design that caused the tragedy but was later discovered that it was because of a managerial decision (Vaughan, 1996)[30]. To address this, and using the Nigerian Space industry as an example, a soft systems perspective on engineering activity that views organizational decision-making was adopted by the author/researcher.

The researcher/author decided to engage the technical managers of both agencies within the Space Industry and employ soft action research to gain an understanding of what their experience decision-making entails, and also what they consider when making these decisions. During the field studies, the practicality of this was challenging as the researcher/author had to contend with the restrictions of face-to-face (F2F) meetings created by the restrictions arising from the Covid-19 pandemic and at the same time maintain the fundamentals of the ideas behind the chosen method.

PEArL Mnemonic; The Words: Authentication and Validation

For an action research enquiry process to be considered authentic ("worthy of belief"), Champion & Stowell (2001, p.7)[31] argued that aspects should be open to public scrutiny, so that concerned individuals could reflect on its applicability to the situation of interest and its acceptability. The PEArL framework was formulated as a methodological tool, rooted in systems ideas, to support claims to authenticity. PEArL is a mnemonic whose original use was to enable this reflection on the authenticity of the research, with respect to Participants, their Engagement, the Authority and relationships in the research exercise and the Learning experienced (the constituent parts making up the framework are shown in Figure 1). Champion and Stowell (2003, p.28)[37] were at pains to state that PEArL is not a guide to action in the enquiry. This must remain agnostic (Checkland, 1985)[12], as the outcome of the enquiry cannot be predicted. However, later studies have shown that it can be used at the start of a study, to consider boundary and participants, throughout the project as a means of understanding who the project is unfolding as well as the means of assessing and explaining the outcome. Cooray (2010)[38] used PEArL in the process of enquiry to help participants examine their ideas about current reality and what ought to be done. The process documentation, in the form of system maps, definitions and models, supports recoverability of the findings, and claims to authenticity are supported by the consideration given to the components. The combination of AIM, as a neutral method helping participants appreciate the situation of interest, and PEArL, as a means of reflecting on the enquiry process throughout, make a powerful combination.

Use of the PEArL framework allows for comprehensive and nuanced reflection at the different stages of an AIM study. Explicit decisions about who "participates" and who doesn't can help set the boundary for the study. Some participants may not be able to "engage" fully with the discussions the method entails; reflecting on how AIM is conducted helps to identify this. "Authority" can be exercised formally and informally and again will have an effect on the study.

It is suggested that the FMA model and the notion of recoverability offer valuable support for guiding the application of theoretical ideas in a practical situation, but that these tools alone are not sufficient as they do not facilitate participants and researchers in gaining an appreciation of the manner in which an inquiry process is undertaken (Champion, 2007, p.456). When doing research collaboratively with others, the way in which inquiry is conducted is as important as establishing the validity of the final outcomes. Champion (2007, pg.451)[33] argues that the FMA model is a valuable tool for planning the application of theoretical ideas in a practical situation, but that, as a guide to Action Research, it still fails to provide a sense of the manner in which an inquiry is undertaken.

Champion & Stowell (2003)[32] have offered the PEArL mnemonic (P—Participants, E—Engagement, A— Authority, r—relationships1 and L—Learning) as a tool to support an Action Researcher in managing the way in which an inquiry is conducted and authenticated (show that the study has been conducted in a way where the outcomes are seen to be well-based). In this research, the PEArL mnemonic is presented as a guide to facilitate researchers, participants, and those interested in gaining an appreciation of the manner in which an inquiry is conducted. PEArL elements are applied alongside the FMA model to provide insight into the dynamic nature of collaborative inquiry and facilitate the flow of the action research cycle to gain a sense of the manner in which an inquiry was undertaken.

The researcher suggests that the application of PEArL in this research offers a guide for both the planning of the field studies and the reflection of it. Below is a diagrammatic representation of the application of PEArL to the cycle of inquiry in action research.

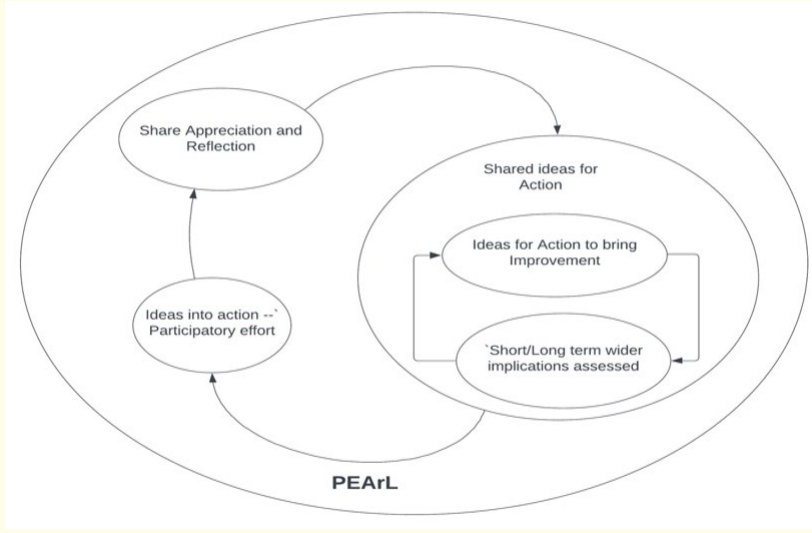

Figure 3: PEArL application to the cycle of inquiry in action Research: adapter from Champion (2007).

The author incorporated PEArL Mnemonic in the research design as a means for authentication throughout the stages of the research (Figure 1). From the choice of participants, the possible consequences of their withdrawing or joining at different stages, the environment and the influence this might have on the studies, to explicit consideration of authority and relationships (how it would be mitigated).

Authentication is the process or action of proving or showing something to be true, genuine or valid (Blackburn, 2008)[34].

Validation is the action of checking or proving the validity or accuracy of something (Blackburn, 2008)[34].

From literature (Hart, 2014[15], p.63; Champion & Stowell, 2001[31]; Cooray, 2010[35]), Hart submitted that 'AIM is an actively used research method, which has evolved to include the concepts of authentication, identification of power dimensions, and the PEArL framework which aided reflection on these. The evolution of the term (Authentication) in AIM study was evident in Hart (2014)[15] work, where the 'socially constructed situation'/activity models developed allowed for authentication of the learning that takes place in the cycle of enquiry (Hart, 2014, p.67)[15]. This means that during the process of constructing a social situation or developing a model in an AIM study, the idea of authentication refers to the process of checking back with the participants to see if their position or assumptions remains the same or true.

This choice of using the word 'authentication' was not evident in the earlier AIM studies (West & Stowell, 1991[36]; Smith, 2001[16]) but model validation in soft system practice was evident in Checkland's work (Checkland, 1995[37]). The choice of the word 'validation' was explicitly used by Smith (2001, p.131 & 145)[16] in her research where she made use of AIM. During the development of the activity models, Smith (2001, p.145) used the term 'validation' to check back with the experts if their position remained valid.

In this paper, the researcher chose to name phase two of the research the authentication phase of the AIM study in accordance with the evolution of AIM practice (Hart, 2014, p.63[15]; Champion & Stowell, 2001[31]; Cooray, 2010[35]). The phase three of the research was named the validation phase to prove that the developed model (D'MHAS) is valid and the studies that informed it are accurate.

Discussion: Outcome and Action for Change

In this section, the author discusses the use of rich picture(See figure 4) in the study to introduce the idea of systemically depicting complex (difficult situations to deal with/represent-messy) situations. It helps to demonstrate research rigour and provide evidence of the investigation/study carried out in the research area of interest. ''In making a 'Rich Picture', the objective is to 'informally', capture, the main entities: the structures of the area of interest and viewpoints of the situation of concern, the current recognized issues and potential ones, and the processes going on'' (Checkland & Poulter, 2006, p.25)[11]. This suggests that Rich Picture can help form the basis of examination that can lead to a better-than-usual level of discussion; because it can help display the multiple relationships involved and reveal the system as a whole.

In developing the Rich Pictures used in this study, the researcher used a familiar system, that is a technical organization which he was part of at a time, therefore, understands the structure and relationships involved. After carrying out the phase one field study and in preparation for phase two, the researcher developed a sketch/draft of the Rich Picture showing the general relationships of the organization with respect to the area of interest (the technical managers). This was improved and developed further by each participant during the interview sessions, and also documented in the transcription. Another Rich Picture was also developed with each of the participants to illustrate the situation of concern which in this case is the technical manager's critical decision-making. Both Rich Pictures were initially drawn by hand, then the main version was later redrawn using a specialised drawing software to aid improved visibility and scalability.

Some lessons learnt from the use of Rich Picture(See figure 4): 1) system thinking skill is invaluable to developing a Rich Picture; an easy way to understand it is to develop one using a known system, 2) a problem or an issue of concern cannot be solved in isolation without the understanding of the overall situation, 3) the interconnection revealed in the rich picture suggests that an attempt to solve a problem can result to another problem being created, or even a new set of problems. In summary, it is important to understand the whole situation of interest before attempting an intervention in any part of it.

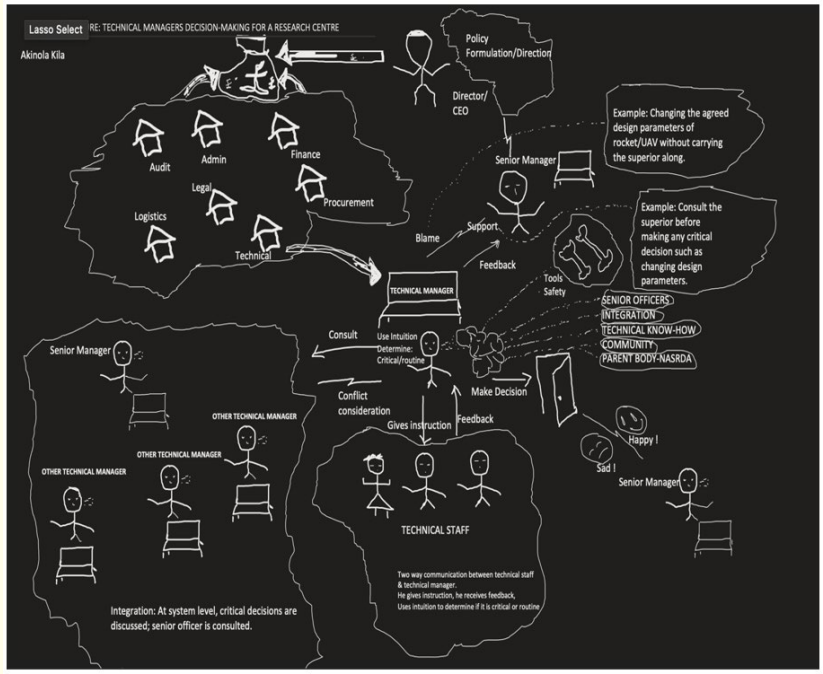

Figure 4: Shows a Rich picture of the situation of interest developed by the participants and the researcher.

AIM Study Outcomes

The shared appreciation developed can be summarised into three main categories: the experts' process of decision-making, the mental classification of decisions into routine and critical ones, and the factors involved/to be considered in the decision-making. The mental classification of decisions into routine or critical suggests the use of intuition and the role of personal traits in decision-making. The factors involved/to be considered in the decision-making can be summarised as: 1. Technical know-how and experience required to generate effective results. 2. Integration with other departments through clear and transparent communication confirms and conveys intent and respect for key stakeholders. 3. Seeking a superior officer's point of view achieves management-level support and provides a requisite for efficient and effective decisions based on experience.

Below are the activities in the root definitions (RDs) and the activity models built together in the follow-up meeting with the participants:

Technical Expertise of Technical Managers

This root definition focuses on the transformation of technical expertise by capacity building. For a decision to be said to have been made in this situation, all these activities (factors) should have been taken into account in order to improve its acceptance by the superiors. Note: Technical Know-How = Technical Expertise.

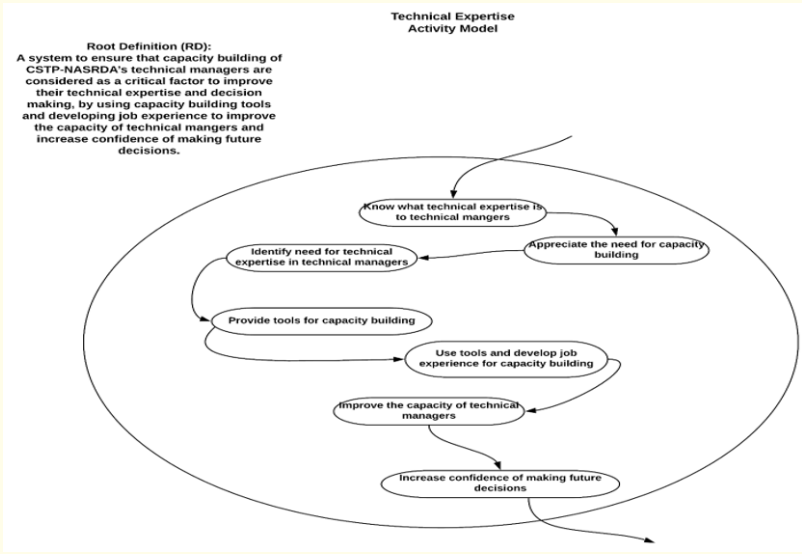

Figure 5: Activity Model for Technical Know-how/expertise.

Below are the key activities in this activity model:

Know what technical expertise is to the technical managers: This refers to the appreciation of specific expertise, its importance and the experience required for the task.

Appreciate the need for capacity building is: This is an appreciation of the specific requirements which serve as a basis upon which the technical expertise can be improved. This could be through the use of identified tools (such as job experience, previous training etc.) for capacity building.

Identify the need for technical expertise in technical managers: This refers to the realisation or quantification of the level of expertise already possessed by the technical manager in order to weigh it against an appropriate capacity building. It could involve relevant certification, degrees, and experience.

Provide tools for capacity building: this could also include relevant equipment, funding and training in key areas.

Use tools and develop job experience for capacity building: This refers to how to build capacity in this situation: how this expertise can be improved in the event that it already exists; how to evaluate if its application is effective; and to also evaluate the kind of feedback. Using tools like targeted training, workshops and seminars.

Identify Job experience: This refers to the identification of necessary job experience that can improve technical expertise. This can be described as time spent on doing the job, internalising and learning from it. This should count in favour of knowledge as practice.

Increase the confidence in making future decisions: This activity refers to the point where the decision is made after the technical expertise has been enhanced by means of improved capacity which will lead to an increase in confidence for future decisions.

These activities, in summary, imply: that the technical managers should know the situation surrounding the capacity building of technical managers by appreciating the importance of technical expertise; know the need for capacity building as means to improve

their expertise; to demonstrate that the technical managers have identified necessary tools to aid capacity building; to appropriately use these tools to improve the capacity of the technical managers; in order to be prepared enough to make an appropriate decision and increase the confidence of making future ones.

This is suggesting that, for the capacity of technical managers to be improved in this situation of interest, they are relevant capacity-building tools that should be identified and used such as relevant staff training to enhance expertise for corresponding technical decisions. The assumption is that, because of the perception that the capacity of the technical managers' expertise is constantly being improved, there should be an increase in the confidence in their present and future decisions.

Integration

This root definition is about incorporating ideas from other departments before a decision is made in order to encourage synergy in the performance of the overall goal of the organisation. For a decision to be said to have been made in this situation, all these activities (factors) should have been taken into account in order to improve its acceptance by the superiors.

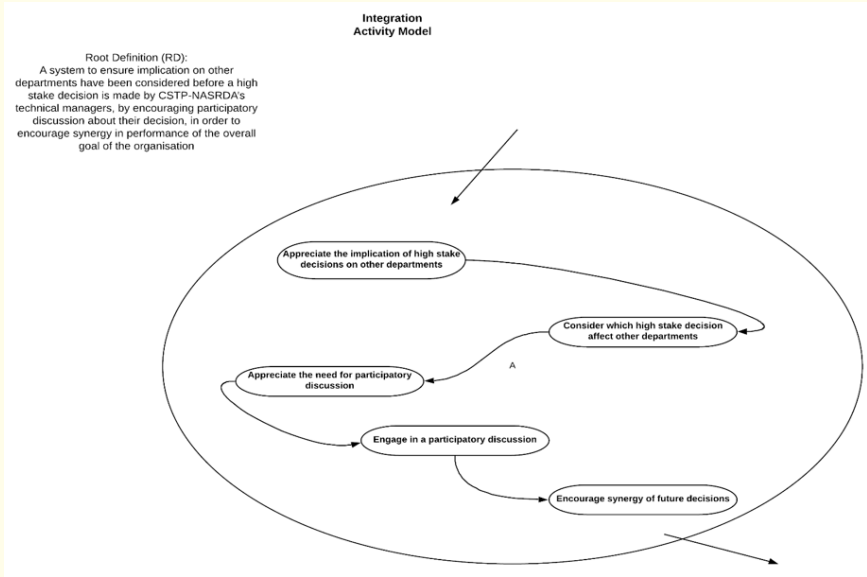

Figure 6: Activity Model for Integration.

Below are the key activities and the activity model:

Appreciate the implication of high-stake decisions on other departments: The area of interest can be described as a complex engineering environment where the departments depend on each other to achieve their aim in construction. This activity, therefore, refers to the appreciation of the need for integration in this situation.

Consider which high-stake decisions affect other departments: This refers to the understanding of what the high-stake decision means to other departments and which of the high-stake decisions is necessary for engagement with other departments. High-stake decisions can be of interest to other departments because of their implication for their output.

Appreciate the need for participatory discussion: After considering the implication of a high-stake decision on other departments, it is important to come to an appreciation of the importance of a participatory discussion to weigh the impact of the high-stake decision on the departments.

Engage in a participatory discussion: This activity is the transformation point before the decision is made. It is the stage where discussions on the implication of the high-stake decision are carried out for synergy in output and encouragement of future decisions.

These activities, in summary, imply: that the technical managers should know the situation surrounding the decision by appreciating the importance of integrating other departmental heads (technical managers) high stake decisions which are also referred to as 'critical decisions'; know what high stake decisions are; to demonstrate that the implication of high stake decisions from other departments has been considered for integration into theirs; to appropriate the need for participatory discussion as a tool for considering the implication of high stake decision and integration; in order to encourage synergy of high stake decision making and increase the likelihood of effective and efficient futures decisions.

Superior officers' influence on technical managers' decision-making

For a decision to be said to have been made in this situation, all these activities (factors) should have been taken into account in order to improve its acceptance by the superiors.

The figure 30 below is the activity model designed for the superior officers' influence showing the activities needed for its transformation:

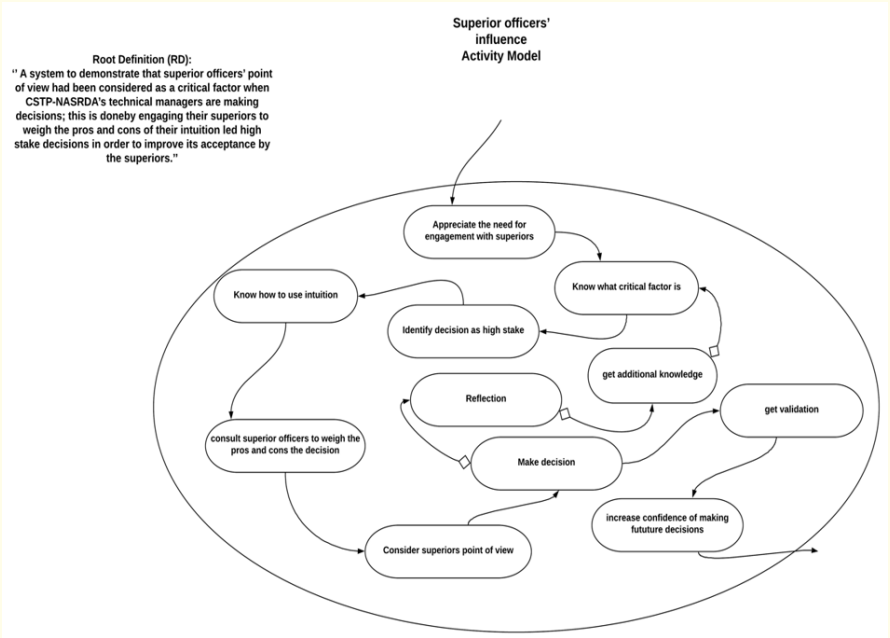

Figure 7: Activity Model for Superior's officers' Influence.

Below are the key activities in the model:

- Appreciate the need for 'engagement' with superiors: this activity is suggesting that the technical managers should know what 'engagement with superiors' means and the need for it. It involves the thinking of the meaning of engagement with superiors and the relevance of the technical managers in the situation of decision making.
- Know what critical factor is: It is important to know what are considered critical factors in this situation. There could be different types of critical factors which could possibly be split into technical, financial and strategic factors and could vary in terms of weight of importance depending on the decision which is about to be made.
- Identify decisions as high stake decisions: From the appreciation of the situation by the technical managers, this activity refers to technical managers' decisions that have the potential to directly affect the aims and objectives of the organisation. A decision which has no direct impact on the mandate of the organisation cannot be regarded as a high stake.
- Know how to use intuition: It is important to know what 'intuition-led alternatives' are in this context. From the appreciation of the situation by the technical managers, this activity suggests that the use of intuition is based on experience for non-high stake decisions. A participatory engagement with superiors and other technical managers was suggested for high stake decisions.
- Consider superior officers' point of view: From the appreciation of the situation by the technical managers, this activity suggests that the directives of a superior should be prioritised even when the technical manager is using his experience-based intuition during decision making.
- Know how to weigh the pros and cons of intuition-led decisions: This activity has to do with the evaluation of the available options based on the technical managers' experience of the situation. He takes into account if this is a high stake decision or not and if it requires further engagement with other departments and superiors.
- Consult superior officers: As suggested by the participants, it is advisable for the technical managers to have a discussion of the situation with the superior officers to get validation and improve their confidence in making future decisions.

Re-examining the activities and the activity model

These activities, in summary, imply: that the technical managers should know the situation surrounding the decision; and what their superiors are inclined to think; to demonstrate that the technical managers have taken the superior's view/directives into account; in order for the superior officers to validate and then back the decision. This suggests that the technical managers make a decision which is guided by their knowledge as practice (intuition led by experience), involving the superiors to give their perspective on the decisions.

The main study findings were largely consistent and they include the following: superior officer's view/opinion, technical know-how and integration with other departments are the most important to the technical managers when making their decisions. It helped inform the development of a framework tagged D'MHAS (Kila & Hart, 2023)[38], which conceives the decision-making process as a human activity system. Within the concept of power-play in decision-making making - the superior officer's influence was found to play a key role in addressing varying judgements or split opinions due to their experience, and also in getting management's support.

From the findings of the studies, the interplay between experience and authority is further examined within the organizational power structure based on the technical managers'/experts' views. One can consider the superior officer's view/opinion as a form or manifestation of casual or soft power, but to the participants, it presents the decision-maker with the relevant options based on experience and implications on other departments of the organization. The idea of the superior's point of view provided not only an option of judgment for the decision-maker but also a layer of security and the feeling of being supported regardless of the outcome of the decision. While this situation might present itself as an influence or a soft or causal power play, it can be viewed as be requisite for efficient and effective decisions within the organization. That is, a measure to enhance the various judgments available at a particular time since superiors are usually more experienced with envisaging possible outcomes of a decision and having an idea of the corresponding impact on integrated departments. This does not necessarily mean what the superior says must be adhered to, rather

it helps improve the options (varieties) available to the technical manager/decision maker from an experienced position rather than a position of authority.

It also resolves the issue of concern amongst the technical managers who worry that their director/superior would not support an individualistic action on critical decisions even if the technical manager feels it is the right call. For example, having perceived and judged a decision to be critical, it is taken into the discern activity where key sub-activities are considered, and the possibility of unifying understanding, accommodating different ideas on judgements amongst key stakeholders involved (in integration with other department sub-activity: other technical managers and superior officer) as shown in the D'MHAS diagram above. After the whole process of consideration and regulation, a specific or consensus judgement is made on a decision. For a consensus judgement which is due to its impact across other relevant departments, the decision must be adhered to, and driven by a common purpose to achieve a common goal. An example of this type of decision is to adopt carbon fibre as the material of choice for a rocket or a specific propellant to achieve a certain mass; these will both impact the structures department, propellant, and rocket fuel department, thrust engines department etc.

The dichotomy between routine and critical decisions brings to the fore the delicate boundary of autonomy that the technical managers/decision-makers possess. While a significant level of autonomy is required for the technical managers to effectively make decisions and discharge their duties, there is also the need to understand that it is not absolute and there is a need to unify ideas, judgements and understanding of critical decisions that could have a major impact on the overall project (as shown in D'MHAS, section 7.1). The author denotes this phenomenon as 'autonomy of function'. This is different from the autonomy of purpose (Beer, 1985)[39]. Autonomy of purpose conceptualizes the system as a purposeful one, in which the actors are driven by a shared interest, while the autonomy of function addresses the responsibility that comes with their autonomy at a personal level in relation to other actors (e.g., a superior officer). Using the concept of autonomy and viability, Kila & Hart (2023)[41] went further to develop an intelligent of control for the organization used in this study. This was done with the cooperation and collaboration of the stakeholders of the organization.

Conclusion

As with all action research, the way that the research unfolds requires flexibility and adjustment. This is particularly the case with soft action research (AIM) as the process itself is a cycle of learning about the situation and the approach. The key though is to maintain the underlying paradigm to prevent the research from declining into anecdotes.

The main part of the research was to explore how decisions are made within this complex engineering organization. The author found out from the literature and also during the studies that the process of decision-making was largely conceived as a step-wise process but with a lot of intuition-based elements which are often unguided and are largely experience-based. There was no structure for a cycle of learning especially for intuition-led decision-making. The author also found out that the decisionmakers relied heavily on their intuitions to classify decision types (Critical or routine) and they are influenced by different social settings and cultural attributes.

From the AIM studies conducted it was found that the rule-based and logical elements of the expertise could be modelled but that the more tacit, intuition-based elements of the expertise, which constitute the engineering and professional judgement of the technical managers, could not be easily modelled. In the concluding part of the research and as a part of a future idea(Kila & Hart, 2023)[38], the researcher suggests decision-making as a human activity model which can be used to manage the intuition-based elements of the technical managers.

The method discussed in this paper can be used to acquire quality data which can be used to develop training prompts for artificial intelligence applications which can also act as a repository for multi criteria decision analysis and algorithm/method for analysis enterprise risk. The overall research is part of the organization's management (CSTP-NASRDA) plan to improve decision-making amongst its technical managers.

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Conflict of interest

N/A.

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