

International Journal of Project Management (IJPM)



**Situating Design Science Research and projects within a
Critical Realist's perspective**

Stephen Kyakulumbye, Anny Katabaazi Bwengye, Shaun Pather



lumbuye et al. (2026)

Situating Design Science Research and Projects within a Critical Realist's perspective

 Stephen Kyakulumbye¹,  Anny Katabaazi Bwengye²,  Shaun Pather³

¹Uganda Management Institute Plot 44-52, Jinja Road, P.O Box 20131 Kampala, Uganda

²Anny Katabaazi Bwengye Uganda Technology and Management University

³Shaun Pather University of the Western Cape South Africa



Article history

Submitted 28.11.2025 Revised Version Received 25.12.2025 Accepted 20.01.2026

Abstract

Purpose: Design scientists, philosophers of science, and project designers hold mixed views on evaluating participatory design research, projects, processes, and outcomes. We argue that design science research produces varied contributions, including theories, methods, and artefacts. From a critical realist perspective, evaluation emphasizes mechanisms-based explanations. This paper examines the role of mechanisms in design science research and shows how studying them enhances statistical approaches for causal inference. It distinguishes statistical from causal inference; discusses mechanisms and mechanism-based explanations; mechanism quantification; mechanisms in explaining individual actions; and mechanisms in explaining outcomes. Drawing lessons from an empathetic participatory design process, it illustrates how design science studies can be situated within critical realism.

Materials and Methods: This study adopts design science research, combining qualitative and quantitative approaches. It includes an extensive literature review and uses empirical statistical data from mechanisms observed in participatory design processes involving prototyped citizen incident reporting applications. Data collection employed qualitative repertory grids with potential citizen users; constructs were then incorporated into a quantitative structured questionnaire for empathetic prototype testing with designers. Prototype evaluation follows the Realist Evaluation model of Context-Mechanism-Outcome Configuration (CMOc), which explains how and why interventions work by analyzing Contexts

(conditions), Mechanisms (activated forces), and Outcomes (intended or unintended results).

Findings: Inferentially, co-designed artifact features show a causal-mechanism relationship to perception (sig.=0.397) and projection (sig.=0.222), but not to understanding (sig.=0.177). Significant causal interrelationships exist among situation awareness constructs. There are also significant relationships between perception and action (sig.=0.382), comprehension and action (sig.=0.312), and projection and action (sig.=0.450). Relationships involving situation awareness constructs, PAL, and e-government artifact adoption were not tested.

Implications to Theory, Practice and Policy: Informed by Personal Constructs Theory (PCT) and Situational Awareness, which view individuals as scientists forming bipolar mental frameworks to interpret and predict the world. The paper advances debates on rigor and relevance in design science research, arguing that a critical realist lens balances rigor (via statistical inference) and relevance (via problem-solving prototypes). Researchers may treat context variables as explicit or implicit ceteris paribus conditions and explore additional causal relationships based on design and evaluation contexts.

Keywords: *JEL codes M15, O33, D83, C18*

M15 - IT Management (*Design Science Research, IS Artefact Design, Evaluation of Information systems*), **C18** - Methodological Issues: General (*Mechanisms-Based Explanation, Causal Vs Statistical Inference, Critical Realism*)

1.0 INTRODUCTION

Design scientists and philosophers of Project Information Systems have mixed and differing views about attention given to the logic of evaluating participatory design research, projects, processes and outcomes. Project Information Systems are purposefully designed human-machine artifacts that significantly impact people, organizations and society (Hevner and Chatterjee, 2010), hence the notion of Design Science Research (DSR). However, it has been revealed from various scientists that there is ongoing confusion, misunderstandings and debate of DSR's central ideas and goals which are hindering it from having a more striking influence on the IS (Gregor and Hevner, 2013) and project management field (Tuunanen, Winter & Brocke, 2024). This was highlighted by Baskerville (2008) who noted that there exist conceptual disagreements about its terminologies, methodologies and evaluation criteria. The use of terms like design science, design research, science of design and design theory interchangeably exacerbated into more disagreements among the IS/PM community. This resulted into the adoption of the term 'Design Science Research' as a broad term meant to encompass the various meanings of all the others (Baskerville, 2008).

From available arguments, various authors attribute the confusion to being beyond a full understanding of how DSR relates to human knowledge, to the appropriate and effective consumption and production of knowledge (Gregor and Hevner, 2013). Among such varied views, emanate other significant debates as to how design science research can be evaluated and what constitutes such evaluation from specific context perspectives. Key questions that arise are whether evaluation of projects in Design Science Research (DSR) should be concerned with evaluation of design science outputs (final projects), including theory and artefacts, and when such evaluations should occur (Pries-Heje, Baskerville and Venable, 2008). Precisely, this paper makes a contribution to the documented lack of consensus among philosophies of science, precisely Critical Realists, as to how statistical inference can be used to study the mechanisms and strengthen the causal inferences during design science research artefact evaluation (Hedström, 2008; Wynn Jr and Williams, 2012; Tsang, 2014). This paper is arranged as follows: a) critical realist's stance about mechanisms; b) a line between statistical and causal inference; c) mechanisms and mechanism-based explanations; d) the role of mechanisms in design science research, e) mechanisms, statistical approaches and causal inferences f) mechanisms and explanation of individual actions; and g) mechanisms and explanation of design artefact outcomes. In regards to ontology, we argue that DSR aims to plan and take action in order to change a part of reality, which ontology has been claimed to be weak due to lack of generalizability (Peffer, Rothenberger, Tuunanen & Vaezi, 2012).

1.1 Problem Statement

In addition to generalizability challenge, Design scientists and philosophers of science together with project designers have mixed and differing views about attention given to the logic of evaluating participatory design research, projects, processes and outcomes. Moreover, design science researches have been over debated regarding the rigour, relevance and the evaluation criteria of generated artifacts. Such negative connotations affect the adoption of design science methodologies for doctoral studies and potential for publication in credible and highly ranking journals. Through this study, we argue that within the whole realm of design science research, there are varying contribution types that include theories, methods and artefacts. From a critical realist's stance, there is considerable attention to evaluation of such contributions through the use of the so-called mechanisms-based explanations.

From a project management and information systems view, positivism assumes a stable, objective reality which project management and information systems do not have. Cicmil,

Williams, Thomas and Hodgson (2006) argue that projects are not objective entities but are enacted through social practices, power relations, and sense-making, challenging positivist assumptions of stability and objectivity. Still on the other hand interpretivism is often seen as philosophically weak for Design Science Research (DSR) because its core purpose does not align with what design science is trying to create artefacts (models, methods, tools). For instance, Hevner, March, Park and Ram (2004). establish that DSR aims to create and evaluate artefacts for utility and effectiveness, not merely interpret social meanings implicitly challenging interpretivist epistemology. Critical realism philosophy fits design science well because: design artefacts intervene in real organizational problems and outcomes are influenced by contextual mechanisms, not universal laws. Bhaskar (1978) establishes the idea of open systems and generative mechanisms, rejecting universal empirical laws in social settings. This is the philosophical basis for arguing that outcomes depend on context. Next is a detailed elucidation of Critical Realist's stance regarding design science projects.

2.0 LITERATURE REVIEW

2.1 Study Theoretical Underpinning

At a meta-theoretical level, Critical realism (CR) was developed by Roy Bhaskar in 1975 as new direction in the philosophy of science and social science, offering a real alternative to positivism and post modernism (Archer, et al., 2013). To be a realist is to assert the existence of some disputed kind of entities such as gravitons, equilibrium, utility, class relations, statistics, econometrics etc (Carlsson, 2006). To be a scientific realist is to assert that these entities exist independent of our investigation of them (Tsang, 2014). This therefore implies that in the social science like in the design science, it is unrealistic to assume that all relevant data will be consistent with a theory even if the theory is correct due to our limited knowledge (Miller & Tsang, 2011).

Based on such arguments, critical realism-based research offers researchers new opportunities to investigate complex organizational phenomena in a holistic manner (Wynn Jr and Williams, 2012). This is due to the arguments that when engaging with complex communities and organizations reductionism is seldom an appropriate choice (Bhaskar and Danermark, 2006; Downward, Finch and Ramsay, 2002). Conversely, approaching a study of some phenomena with a degree of institutionalized blindness and shielding social life from off stratified levels "beneath" is problematic and inappropriate (Carolan, 2005). Investigating complex organizational phenomena in a holistic manner helps to identify the mechanisms which connect chains of indeterminate events and social interactions (Wynn Jr and Williams, 2012).

From the foregoing debates, Critical realism reshapes DSR by shifting the focus from artefact effectiveness alone to explanatory depth: *why* an artefact works, *for whom*, and *under what conditions*. From "does it work?" to "what mechanisms does it activate?" the ontological implication of Critical realism assumes: a stratified reality (empirical, actual, real) and outcomes arise from generative mechanisms in open systems. The Methodological consequence in CR-informed DSR: are that artefact evaluation does not stop at performance outcomes implying that one explicitly theorizes the mechanisms the artefact is intended to trigger. For example, Example in project management instead of claiming: "The e-governance framework improved decision quality," one would probe "Which organisational mechanisms (e.g. role clarity, accountability, information symmetry) were activated, and how did context shape their operation?" (Pawson & Tilley, 1997).

Using Information Systems project designs, Design Theory is a theory of how to do something (Gregor, 2006). It is about principles of form and function, methods and justificatory theoretical knowledge that are used in development of information systems (Walls *et al.*, 1992; Gregor &

Jones, 2004; Gregor, 2006; Gregor & Jones, 2007). Most of the design-related theories are anchored in Simon’s book (1980) *Science of the Artificial*. Simon’s work holds two key assumptions that design of an intellectual structure should aim at accommodating those empirical phenomena that are “artificial” rather than “natural,” hence the need to consider human psychology in design. Simon further notes that any system being developed must have a given form and behaviour because they adapt or are adapted, in reference to goals or purposes to their environment (Kyakulumbye et al, 2020). A number of design related theories have been advanced within varied philosophical orientations and are presented in Kyakulumbye’s et al, 2020 summary theoretical table below:

DSRIS	Design Science Research in Information Systems	An information systems research methodology in which new knowledge is produced by the construction of artefacts informed by practice based insight or theory; evaluation of artefacts using human information processing criteria and reflection on the process and implication of design outcome (empathetic design).
ISDT	Information Systems Design Theory	Conceptualised as a set of prescriptive statements describing how a class of artefacts should behave and how they can be constructed, why the artefact behaves the way it behaves and under what circumstances.
DREPT	Design Relevant Explanatory/Predictive Theory	A type of theory that augments the “how” information content of the traditional ISDT with explanatory information why the artefacts has the effects it exhibits. The explanatory information may borrow theoretical information from other disciplines.
ISDST	Information Systems Design Science Theory	This perspective argues that IS is a socio-technical discipline and that design science research must acknowledge that design is fundamentally a human activity
PCT	Personal Constructs Theory	This is a human information system processing model that espouses that humans make value judgment using extremes of bipolar constructions (negatives vs positives). It elicits perceptions of intended system users without designer and researcher bias.
SAT	Situation Awareness Theory	This elaborates the PCT by observing that construct naming during artefact evaluation is beyond perceptual human information system processing to comprehension and project within a given situation and context. The perception, comprehension and projection later guide decision and actions taken by individuals.
CMOC	Context Mechanism Outcome configuration	A critical realist’s artefact evaluation framework for examining whether a designed solution works, for whom and under what circumstances.

Source: Kyakulumbye et al, 2020.

As has already been noted in the foregoing sections, all the above theories have been premised on Simon’s work: Walls, Widmeyer and El Sawy’s (1992) building of an Information System Design Theory for vigilant Executive Information Systems; Hevner and Chatterjee’s (2010) Design Science Research in Information Systems; Design Science Research by March and Smith (1995); Kuechler and Vaishnavi’s (2008) Design Science Research in Information Systems; and Carlsson’s (2006, 2010) Information Systems Design Science Research. Philosophical problems associated with building a unified and coherent cross-disciplinary body of knowledge and theory associated with designing and designs have been observed (Love, 2000; Love, 2002). From all the design theories reviewed, Information Systems Design Science theory by Carlsson (2006) candidly offers defence and relevancy as to why design work should be situated within Critical Realism lens.

Using Information Systems Design Science theory and based on some of the documented theoretical limitations, Carlsson (2006) builds on McKay and Marshall (2005) who argue that

IS is a socio-technical discipline and that design science research must acknowledge that design is fundamentally a human activity. Carlsson emphasizes that context of design and use is critical, and that research paradigms, practices and activities must embrace a worldview or philosophy. Two major gaps filled by Carlsson's ISDST theoretical perspective is situating it under a philosophical paradigm and an evaluation perspective (Carlsson, 2003), which builds on critical realism and realist evaluation (Pawson & Tilly, 1997). From a similar evaluation perspective and meta-scientific theoretical lens, the intention of design science projects in this study answers the questions why and how an IS initiative works, for whom, and in what circumstances. The IS being designed must have the potential to cause the desired change.

To that note, the IS design science researcher aiming at theory building works as an experimental scientist, but not according to the logic of the traditional experimental evaluation researcher. The experimental scientist must trigger the mechanisms under study to ensure that it is active (Bhaskar, 2002). This paper is supportive of Carlsson (2006), who revealed that IS design researchers do not perceive that IS initiatives work. It is the actions and non-actions of the intended users that make them work and the casual potential of an IS initiative provides reasons and resources to allow design participants to make changes. From an evaluation standpoint, IS design researchers orient their thinking to context, mechanism and outcome pattern configurations (CMOCs) (Pawson & Tilley, 1994; 1997).

2.2 Mechanisms and Mechanism-Based Explanations

Perceiving design science research in general and participatory design research in particular from a mechanism-based approach, is that we explain what happens during the process by specifying the mechanisms by which what we wish to explain was brought about. Mechanisms, during any scientific enquiry operate prior to and independently of their discovery (Archer, et al., 2013; Tsang, 2014). It is asserted that our inability to fully know or describe future events does not imply that mechanisms do not exist (Ron, 2002). Critical realism recognizes the reality of the natural order and the events and discourses of the social world and that mechanisms connect events and their social interactions (Fleetwood, 2002). To properly understand the notion of mechanisms, Bhaskar (2014) outlines three domains: the *real*, the *actual* and the *empirical* (figure 1):

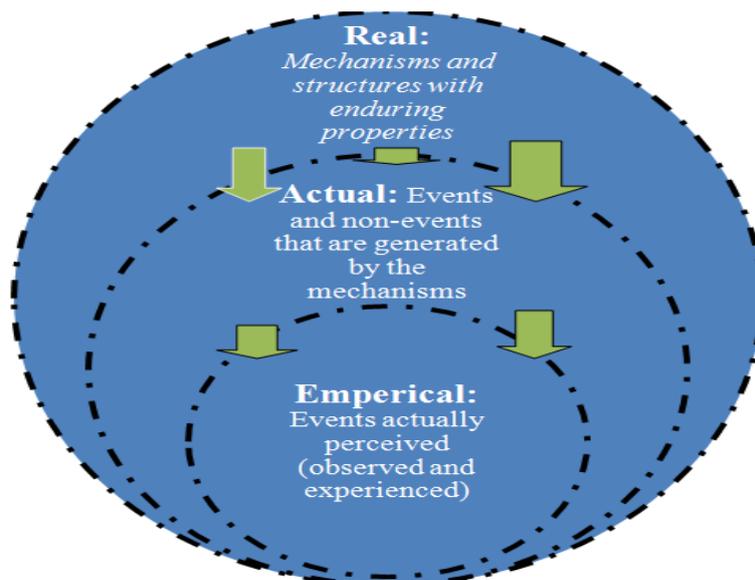


Figure 1: Critical Realist's View of Science

Source: Researcher Generated

The real domain consists of underlying structures and mechanisms (observed and unobservable), and relations; events and behavior and experiences (Archer et al., 2013). The real or deep structures and mechanisms generate the phenomena (McEvoy and Richards, 2006). The generative mechanisms residing in the real domain exist independently of, but capable of producing patterns of events in the actual domain (Carlsson, 2006). Relations generate behaviors in the social world (Tsang, 2014). The domain of the actual consists of these events and behaviors or those aspects of reality occur, but may necessarily not be experienced (Ron, 2002).

Hence the actual domain is the domain in which observed events and observed patterns of events occur (Carlsson, 2006). The domain of the empirical consists of what we experience either directly or indirectly; hence it is the domain of experienced events (McEvoy and Richards, 2006). During scientific investigations, whereas we want to apprehend the causal mechanisms, they cannot be apprehended directly as they are not open to observations, but they can be inferred through a combination of empirical investigation and theory construction (Ron, 2002; McEvoy and Richards, 2006; Hedström, 2008). The ability to observe some of the events and their patterns in the actual and empirical domain, implies that whereas social phenomena is open, scientific investigation can take form of quasi-closure (Downward, 2016; Downward & Mearman, 2005). The same philosophy could underlie project design

From a project management perspective, Project design informed by critical realism involves a methodology that looks beyond observable events to uncover the underlying, often invisible, mechanisms, structures, and causal powers that produce them (Roberts, 2014). This approach uses a three-layered ontology, the empirical, the actual, and the real, to provide a more complete, holistic, and context-sensitive understanding of a project's complexities and potential for improvement. From a research perspective, this calls for quasi experimentation.

Quasi-closure is some form of stable conditions and mechanisms within a social system upon which people base their behavior though not pervasive closure as applied in mainstream economics (Downward, Finch & Ramsay, 2002). Under normal circumstances, it can be argued that society and mechanisms under play reflects shared or at least overlapping and mutually consistent, mental models that could approximate, closure, though not total closure like in a purely closed system. Extremists to the so-called mechanisms of one school of thought have advanced that there are universal mechanisms of causation and the other school of thought has argued that there are not any generalizable mechanisms of causation in human endeavors (*For details, see Iannacci & Hatzaras, 2012*). Within critical realism, as within the real world of technology implementations, bringing about an effect from a cause is dependent upon both causal mechanism and causal context (Fox & Do, 2013).

However, there is an overabundance of definitions of 'mechanism' with no consensus of what this term exactly means (Hedström, 2008). Philosophers and Scientists have defined it in very many different ways and table 1 below provides a snapshot of varying views:

Table 1: Scholarly Conceptualization of Mechanisms

Author (s)	Definition	References
Biesbroek	Patterns of interactions between actors that bring about change in the governance process that led to policy impasses.	Biesbroek, Termeer, Klostermann and Kabat (2014)
Archer	Aspects of reality that underpin, generate or facilitate the actual phenomena that we may (or may not) experience.	Archer, Bhaskar, Collier, Lawson and Norrie (2013)
Elsenbroich	Entities at work producing social phenomena.	Elsenbroich (2012)
Wynn	Entities that connect chains of intermediate events and complex interactions that allow researchers to develop and support in-depth causal explanations for the outcomes of sociotechnical phenomena.	Wynn and Williams, (2012)
Hedström	Entities (with their properties) and activities that these entities engage in, either by themselves or in concert with other entities.	Hedström (2008)
Carlsson	Plurality of structures that generate the events that occur and do not occur.	Carlsson (2006)
Downward	Necessary relations and events that lie behind and govern the flux of events in an essentially open world.	Downward, Finchand Ramsay (2002)
Ron	Hidden or not hidden, mechanisms produce the events scientists seek to explain.	Ron (2002)

With all the varied conceptualizations of the same concept, it is emphasized that researchers looking for examples with clearly labeled mechanisms refer to Pawson and Tilley's classic realist example of mechanisms through Context mechanisms Outcome Configuration (CMOc) (Rogers & Weiss, 2007). The authors use a metaphor of a closed-circuit television in parking lots and how it might work to reduce auto theft through the mechanism detection, capture and removal of thieves; through deterrence; through passive surveillance among others (Pawson & Tilley, 1997; Rogers & Weiss, 2007). Mechanisms are ways of acting of things (Bhaskar, 1975: 14; Pawson & Tilley, 1997). They are inherent to physical and social structures, enabling or constraining what can happen within a given context and can be conceptualized as causal powers or tendencies (Wynn Jr & Williams, 2012).

Whereas most conceptualizations of 'mechanism' are similar or differentiated, the most satisfactory conceptual analysis based on design science research of mechanism concept are found in most definitions that bring out entities and activities that result from patterns of interactions between actors and their outcomes. To clearly define mechanisms under design science research, there is need to be aware that participatory design has causal powers that result into observed and unobserved events among the team members. Implying that Mechanisms can aid theory building.

Astbury and Leeuw (2010) offer a clear link between mechanisms and theory building when they highlight the importance of casual mechanisms to explain how and why programs work and under what circumstances. Whereas there is conceptual confusion of relegating mechanisms to the program activity, from a design perspective, mechanisms are conceptualized as the observable or unobservable attributes that bring about the change (positive or negative) in a unit of analysis. The change may include motivation, engagement or disengagement, empowerment, enhanced knowledge and awareness, sense of feeling to have contributed to a given cause; also termed as theoretical mechanisms (Hedström, 2008; Astbury & Leeuw, 2010). These could be explained by some statistics where a researcher may seek to examine

the explanatory power of how X may cause Y, referred to as statistical theorizing (Hedström, 2008). In a critical realist (CR) Design Science study, participatory design is not justified primarily on ethical or democratic grounds, but because it is a mechanism for activating causal powers that enable an artefact to work in practice as an empowerment mechanism (Carlsson, 2005). To that regard therefore, participatory design is analytically examined as a way of altering structural constraints, not merely “giving voice”.

2.3 Mechanisms, Causal Inferences and Statistical Inference/Theorizing

From foregoing debates, mechanisms can result into observable or unobservable events. The casual mechanisms that generate unobservable events can be used for making statistical associations, referring to things that are not visible in the data (Imbens & Rubin, 2015). Similarly, Downward, Finch and Ramsay (2002) position clears the scientific space by arguing for a modified ontological position from the philosophically pure case of an open system, to one which suggests that in social systems individual and institutional experiments exist by use of what they term as quasi-closure. The authors guide that quasi-closure can provide leverage for researchers seeking to validate and generalize empirical insights about economic processes. The nature of what is potentially a completely open system is modified as a direct consequence of human action (Wynn & Williams, 2012).

In fact, Downward and Mearman (2002) emphasize the need to clear the Post Keynesian economics who are allied to critical realism and use statistical modeling and the many of the epistemological pronouncements of critical realism who are still suspicious of econometric methods. The authors guide that drawing upon post Keynesian economics, a useful symbiosis of ideas is produced which has positive implications for the practice of critical-realist empirical work in efforts to examine mechanisms under play (idem, 391).

Whereas mechanisms can generate effects and outcomes, it can involve irreducibly stochastic (unpredictable and without a stable pattern or order) elements and thus affect the probability of a given effect (Hedström & Ylikoski, 2010). Whereas causal inference and statistical inference, are similar in that they both use “localized” information to draw conclusions about more general phenomena; however, the types of phenomena about which one seeks to generalize are not the same and the types of information used also often differ (Hedström, 2008). To my own knowledge and experience, a statistical model can say something about causation. Statistical inference needs to help researchers measure the effects of causes generated by casual mechanisms (Holland, 1986).

In so doing, one would be curious whether to emphasize the relationships that could be a cause of effects or the effects that could be brought about by relationships of causes. In my opinion, as a way of bringing statistical reasoning/inference to bear on the analysis that a relationship of some sort could have a degree of mechanism causation, hence putting emphasis on effects of relationships and causes. For example, the magnitude of a change in Y effect (the observed) as explained by X_1, X_2, \dots, X_n (causal mechanisms).

Therefore, an effort to apprehend such mechanisms calls for a blend of statistical and causal inferences. Meanwhile, we provide a distinction between statistical and casual inference we refer to in this paper.

2.4 A Line Between Statistical and Causal Inference

Casual inference is not the same as statistical inference, though their similarity is that they both use localized information to draw conclusions about more general phenomena (Hedström, 2008). It is observed that the types of phenomena about which one seeks to generalize and the types of information often used differ. If causal inference is different from statistical inference,

the question that this paper seeks to clarify is how researchers use statistics to study the mechanisms within design science research? This question will be alluded to later in this paper. Casual inference is a term not necessarily confined to a statistical sample and the entity one seeks to generalize about, but the process by which something has been brought about by the mechanisms governing the process (Ron, 2002).

However, it is observed that knowing relevant mechanisms is necessary for statistical inference and estimates are important to understand the process by which something has been brought about (Hedström, 2008). Under causal inference, the focus is not on relationships between variables, but on the triggers, actors, their relationships and the intended and unintended outcomes of their actions, under this case, researchers, system designers and system users. To that note, casual inference is an inference mode in which events are explained by postulating (and identifying) mechanisms which are capable of producing them (Sayer, 1992; Wynn Jr and Williams, 2012). Discerning among these domains needs a form of situation awareness hence situation awareness theory as an underpinning theory for this paper. Using Situation Awareness Theory, our results offer answers to longstanding questions regarding artifact categorization, such as whether there are underlying causal models for artifacts, which properties are part of them, whether design history is an artifact's causal essence, and the most central artifact property. The evaluative questions statistics that can legitimately offer answers to the artifact qualities are guided by the situation awareness lens of perception, comprehension and projection and how they predict action generated by mechanisms of the artifact.

2.5 Theory Verification and Falsification in Critical Realism Studies

From a critical realist's view, a reality ontology and *fallibilists* epistemology motivates efforts towards falsifying or verifying theories in order to advance scientific knowledge (Miller & Tsang, 2011). The authors like other critical realists' authors further acknowledge the potential fallibility of all knowledge claims and supports modesty regarding verification and falsification alike (id. 140). In this paper, we acknowledge that fallibility (falsification and verification) is used in social science research context not physical science where some theories are believed to be non-falsifiable or hardly refutable (Baert, 1996).

Moreover, empirical corroboration or refutations (falsifiability) of theories under social science and design science count a great deal (Mingers, 2004). The call for corroboration aids critical realist scientists to search for empirical regularities while at the same time catering for the irregularities that do fall outside the statistical and causal theoretical models (Zachariadis *et al.*, 2013). Similarly, Tsang and Kwan (1999) echoed the role played by replication in theory development proposing a multifocal pattern of knowledge accumulation during critical realism scientific investigations. Such debates imply that the verification of a theory aids its replicability, and therefore statistics has contribution to offer an explanatory power to the theoretical models.

Similarly, authors attest to the fact that theory verifications and falsifications under critical realism are consistent with notions of consensus and coherence of truth (Bisman, 2010). By consensus, an observation sentence is true when there is a group agreement, while coherence implies that an observation sentence is warrantable only if it is provable with a theory (id. 10). This implies that under critical realism, where alternative theories exist to explain an action or event, the theory acceptance is established by choosing an alternative that allows us to construct a consistent and coherent account of our experiences. Notwithstanding, the fallibility of knowledge that guide our experiences or vice versa, does not logically entail that all knowledge is equally fallible (Smith, 2006); meaning, the inability for a theory to fit our data may not necessarily falsify this theory in other contexts. This is one major reason that requires critical

researchers not to contend to just only description; qualitative or quantitative, but to treat a given research methodology however complex it may be to be the first step in the research endeavor (Mingers, 2004).

Getting beneath the surface to understand and explain why things are as they are, to hypothesize structures and mechanisms that shape observable events, then calls for empirical corroborations. In this paper, the advance of statistical inference to explain causal mechanisms furthers is not the end but just some means towards an end. The use of statistical data presupposes that our perceptions of data give us an indication and explanations of the way mechanisms and mechanisms-based explanations are under play. To guide statistical use, we use a theoretical lens based on Situation Awareness Constructs.

2.6 Situation Awareness Theory (SAT)

Situational awareness, by Endsley (1995) incorporates almost all variables involved in a comprehensive theory of human behaviour, with particular attention to its cognitive elements (Bedny & Meister, 1999). SAT espouses that the state of environment influences how we perceive different situations, how we understand the current situation and how we project future solutions in order to take action. Perception, comprehension and projection are the situation awareness cognitive criteria that have explanatory sub-constructs. They dictate the kind of decisions one makes and the ultimate action performed.

Situational Awareness theory, as advanced by Endsley (1995) incorporates almost all variables involved in a comprehensive theory of human behavior, with particular attention to its cognitive elements (Bedny and Meister, 1999). The model has three major cognitive process humans undergo through any information processing initiative:

- Perception is an attention-based selection of task requirements. It includes affordance- which implies how an application should be used; consistency, familiarity, recognizability, visibility, benefit expectations.
- Comprehension is an understanding of perceived information about a particular situation. It includes learnability, association, generalization, informative, ease of use.
- Projection includes feedback, user centeredness, support, user confidence, meaningfulness, prediction, pop up messages, signal displays and error detection functions among others.

Of recent, several scholars have employed situation awareness theory in simulated technological contexts. For instance, in a medical environment, Wright, Taekman and Endsley (2004) have observed that one major limitation in the use of human patient simulators is a lack of objective, validated measures of human performance. The authors argue that objective measures are necessary if simulators are to be used to evaluate the skills and training of medical practitioners and teams or to evaluate the impact of new processes or equipment design on overall system performance.

Of most recent, Rosli (2015) have adopted situation awareness theory to examine the cognitive awareness prototype development on user interface design. Seo (2016) have adopted situation awareness constructs in a study on interaction-driven comparison between analog and digital gaming control interface on smart phone. From a participatory design context, Olsson and Jansson (2005) have used situation awareness criteria in a study among train drivers and report that in order to produce usable systems, quality time has to be spent initially to acquire knowledge of a work domain and establishing a common ground in terms of shared knowledge and a better understanding of the work context between the parties involved in system development.

From a design perspective therefore, it is hypothesized that participatory design has the ability to harmonize situation awareness constructs, individual factors, task/system and contextual factors. This is because such constructs can trigger a user's observed and unobserved mechanisms within a given context. These mechanisms lead to a decision by a user to perform observable or unobservable events. As underpinned by SAT, its main focus is context or design situations and how mechanisms operate within such varied contexts. For instance, Patrick and Morgan (2010) observe that counterintuitive methods to cognitive engineering and interface design are described that can improve aspects of SA, depending upon what criteria of task performance are important, by encouraging a person to adopt a more cognitive-based interaction strategy. Whereas CR focuses primarily on closed systems, a more accurate explanation of reality is obtained in addition to the identification of contextual causal mechanisms (particular situations) in the context of study when a general systems theory is applied (Lawani, 2021).

2.7 Research Gaps

From the available studies, whereas gaps with design science research that relate to rigor, relevance and artifact evaluation criteria of the research outputs are acknowledged, the studies do not reveal how such gaps can be bridged. Such gap filling is at the heart of this study.

3.0 METHODS AND MATERIALS

The empathetic participatory design framed within participatory action research design methods and paradigm comprised twenty-eight (28) co-design team members worked in four groups to design four different artifacts. Sampling was by census involving all the 28 students undertaking their third-year degree in Business Computing course as co-design participants. Participatory designer teams can be assembled from a group of community-dwelling adult citizens and/or students in university research labs (Ellis and Kurniawan, 2000). This study sought to co-design with students in a university setting. Druin, 2002; Druin, (2010) describes four possible roles of students during participatory design process:

- As a user (who can be observed or assessed).
- As a tester (who is also asked for comments).
- As an informant (who offers feedback and input).
- As a design partner (considered as equal stakeholder in the design process).

However, while working with students as design partners, it is stressed that mature adult designers with highly formalized knowledge and experiential tacit knowledge should be gatekeepers to the design processes (Bovill and Bulley, 2011; Bovill, Bulley and Morss, 2011).

In participatory design, the researchers and co-designers double their roles as participants as well in order to simulate the lived experiences of the researched. This is because co-design team members bring forth their tacit and explicit design knowledge to enrich the design process and outcome before and during the typical user experiencing design phase. I referred to this approach of design as 'empathetic participatory design' as adopted and modified from (Lindsay et al., 2012; Kouprie and Visser, 2009; Hawley, 2007; Sanders, 2003) who termed it 'empathetic user experience design.' It is empathetic as it highlights the importance of the design team to better understand a prospective user audience by living through common experiences or facing the same challenges related to usability as users may face.

This study includes the participatory component since the simulated artefacts were taken before the potential users on several iterations (some informal and formal iterations) to further

generate user views based on their hands-on usage in order to improve the designs. Some other scholars have referred to such empathetic design behavioural simulation (Hensen and Lamberts, 2012).

3.1 The Statistical Model from the Theoretical Framework

The regression model developed from the Situation Awareness Theory (SAT) with open constructs of perception, comprehension and projection; that ultimately influence decision/action taken is used as a lens to look at the data. The data that falls outside the constructed model is given explanations through abduction and retroduction as advanced by Peirce (1957). As Meyer and Lunnay (2013) opine, using deductive inference, the theoretical lens is proved or disproved, leaving findings that lie outside the initial theoretical mold unanalyzed.

However, abduction allows the researcher to formulate new ideas and think of something in a different context in order to see something else (Danermark *et al.*, 2012). Unlike abduction, retroduction allows the researcher to move beyond the conceptual apparatus and begin to question and clarify the basis of prerequisites or conditions for priori assumptions or theoretical frameworks (Meyer & Lunnay, 2013). Tsang (2014) notes that retroduction aids critical realists to generate mechanistic explanations the researcher takes some unexplained phenomenon and proposes hypothetical mechanisms that, if they existed, would generate or cause that which is to be explained.

Unlike other technology adoption models like TAM, UTAUT, TRA, etc; Situation Awareness Theory is an open construct theoretical framework that has the ability to encompass most of the adoption constructs to fit or align with it. The original author of SAT attests to my submission by suggesting that although it may be difficult to test the model as a whole, excellent research has been conducted to test and extend various aspects of it (Endsley, 2015). For instance, the original Davis' (1985) TAM, has three constructs that have a perceived causal effect onto adoption.

Extensions of the model have added more constructs to improve the so called causal explanatory effects, but the effect has remained low over years of less than 45%. As revealed, there are variations in results of the theories to predict behavioral intentions in Venkatesh et al (2003, 2011) UTAUT model that combines Fishbein & Ajzen (1975) Theory of Reasoned Action and Davis (1985) Technology Acceptance Model. Some authors report explanatory variance of 35.3% without interaction mechanisms and others 39.1% with interaction mechanisms (Thomas, Singh and Gaffar, 2013).

Through this design process-based research, the artefact evaluation revealed over 130 constructs which were then framed into a close ended tool using SAT and verified during the empathetic participatory design process. The repertory grids, the qualitative data analytics method that generated the constructs, is out of scope of this paper. The explanatory power of the constructs as causal mechanisms of decision or action takes is well elucidated in the results section. In this paper, emphasis made is that the statistical model was used to fit onto the data, not data being fitted to the theoretical and statistical model. This is therefore an adaptation of Tsang and Miller process of statistical inference under critical realism data analytics values. The details of the tool, theoretical lens and statistical modeling are provided in the next section.

3.2 Conceptual Framework

Using Situation Awareness Theory (Endsley, 1995), within a Critical Realist lens, a close ended artefact evaluation tool was designed. The theory was only a stepping stone for construct naming and identification of data that was not aligning with this lens for detailed mechanism

identification and explanation. The dimensions of the questionnaire were: perception, comprehension, projection and participatory action learning as depicted in the figure. This tool was developed on a scale of 1-5 from strongly disagree and strongly agree respectively, was used to collect quantitative data from the co-design team members during the empathetic participatory design.

Below in the conceptual framework model (figure 2) is the theoretical model that guided this paper depicting the effects of the outcome that can be explained by the causes in the model, when a mechanism (artefact design from an empathetic participatory design process) is introduced.

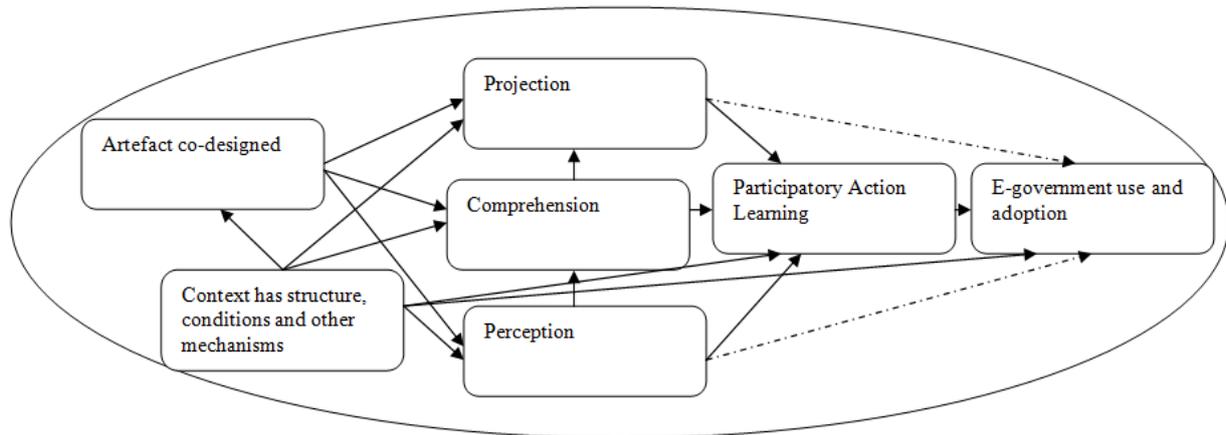
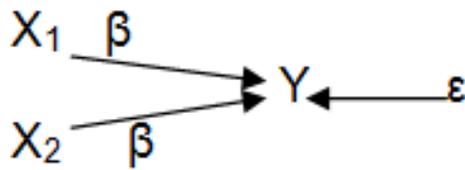


Figure 2: Conceptual Framework/ Theoretical Artefact Evaluation Model

Source; Researcher (2025)

From the above path diagram, it can be hypothesized that context is key during interface and application design (intervention) as it has generated mechanisms that affect how actual design happens, it has a bearing on the way a user cognitive criterion of an interface. The application designed influences the user cognitive criteria, while levels of cognitive criteria could operate in successor manner, but each criterion could have a different effect on the participatory action learning, which later influences decision to use and adopt e-government applications. In this study, context is treated as explicit or implicit *caterisparibus* condition, implying that the theoretical system is closed. Exclusions of the mode are context and application use and adoption as it requires more lengthy field observation.

From the conceptual path diagram, the structural equations were assumed where each construct of interest is a casual mechanism as conducted using abduction and retrodution in order to offer an explanation as to why the results may fit or fail to fit the theoretical lens (Miller and Tsang, 2011: p.148). Bhaskar maintains that people's reasons can operate as causes, which in turn are responsible for producing or inhibiting change (Bhaskar, 2014). Several other scholars have called upon such modelling that has interest in subject knowledge, beliefs and judgments of those concerned with the situations while focusing on causal structures and mechanisms (Mingers, 2006: p.213). From this study view, the designed applications take the form of dummy variables where reference categories in the model are coded (1) and the no-reference cases as "0" as and when required. The following hypotheses as presented in the structural equations are tested using ordinary least squares regression methods based on:



- Perc = β₁App + ε₁.....(i)
- Comp = β₂App + ε₂.....(ii)
- Proj = β₃App + ε₃.....(iii)
- Adopt = β₁Perc + ε₁.....(iv)
- Adopt = β₃Proj + ε₃.....(v)
- Adopt = β₄PAL + ε₅.....(vi)
- PAL/Decision = β₁Proj + β₂Comp + β₃Proj + ε₄.....(vii)

Where the hypothesized mechanisms β link X₁ and X₂ (causal variables) respectively, to Y (output variable). The ε is assumed to occur since the model may not fully represent the actual relationships between the casual and outcome variable. A give App results into variations in β and variations in X. Variations in X₁, X₂...X_n result into variations in PAL (Y).

Perc is perception; Comp is comprehension, Proj is Projection, App is Applications (ReportIt, Quick App, FindMe and UBus), PAL is participatory action learning from the low, middle and high-fidelity prototyping tools; β are the hypothesized mechanisms that link the independent variable and the dependent variable, ε is assumed to occur since the model may not fully represent the actual relationships between outcome and input mechanisms.

4.0 FINDINGS

Whereas critical realist studies rarely present statistical descriptive results, they are deemed necessary to provide a rough idea regarding the operation of the causal mechanisms within a given study context. Next, we present Cronbach reliability test statistics and the Ordinary least squares regression results.

4.1 Reliability of Results (Composite Constructs) Based on Realism and Value

The tools were checked for reliability using Cronbach alpha score using interrater or interobserver reliability. Below are construct results in the table:

Table 2: Summary of Cronbach Alpha Results for Reliability Check

Latent variable	Number of Observable Variables	Cronbach Alpha
Perception	12	0.844
Comprehension	10	0.758
Projection	14	0.777
Participatory action learning	10	0.690
Total items in the tool used under this study	46	

Reporting about reliability of a toll provides future users of the instrument at least minimal information on which to move its development forward. Whereas most reliability results are used to assess transferability and replicability, this Cronbach assessment is for realism (some form of truthfulness that can be a basis for verification or falsification) and value (truth to be grounded on facts) of the tool (Kardong-Edgren, et al, 2010). Cronbach alpha is a measure of

internal consistency in quantitative studies. We use item analysis for measuring the correlation of each item with the other underlying constructs (Pather & Uys, 2008).

In terms of mechanisms operating among study participants, item analysis differentiates between respondents having high total and low total scores on summarized Likert scale items. Treating likert scale data in increasing ordinal order (strongly disagree=1 through strongly agree=5), item analysis calculates mean for each item and applies it to find significant differences between the means of high scorers (in the highest 25 percentile) and low scorers (in the lowest 25 percentile) on the scale (Pather & Uys, 2008). Unlike split half technique, the responses are not divided into two random groups.

4.2 Composite Construct and the Respective Item Results

There is need to reveal what constituted each of the composite constructs and the contributing mechanisms to each of them. Below are item analysis results of the constructs and their respective Cronbach alpha:

Table 3: Perception Measures Results

Reliability Statistics				
Cronbach's Alpha		N of Items		
.844		12		
Item-Total Statistics				
Constructs	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Colors attracted my attention	40.18	45.016	.702	.816
Colors can be seen from a far	39.65	47.506	.618	.824
The icons are visible enough	39.77	47.310	.675	.819
The icons/pictures are understandable	39.61	50.049	.538	.830
Words are easy to understand	39.49	53.458	.344	.843
I can easily recall information on the app	39.77	53.599	.380	.841
The functions or parts are well integrated	39.57	54.248	.330	.844
Instructions are short enough and simple	39.63	54.356	.247	.850
Information is easy to find	39.63	52.501	.388	.841
The colors attracted my attention	40.17	45.948	.684	.818
Colors can even be seen using naked eyes.	39.63	48.669	.582	.827
The icons are visible enough	39.56	49.406	.547	.830

Table 4: Comprehension Measures Results

Reliability Statistics	
Cronbach's Alpha	N of Items
.758	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
The system is easy to use	32.36	23.148	.545	.721
App can be easily used by novice users	32.65	23.506	.443	.735
Labels are useful for novice users	32.26	25.063	.336	.749
The information displayed on the system is easy to understand	32.12	24.419	.398	.741
The system is easy to learn	32.20	23.754	.490	.729
The system is informative	32.25	23.901	.444	.735
Short notes offer quick guidance	32.39	23.181	.457	.733
It is easy to recall steps for working with this app	32.52	24.228	.338	.751
The system seems safe to use it	32.23	23.527	.494	.728
It is easy to use similar applications on other phones	32.48	24.252	.301	.758

Table 5: Project Measures Results

Reliability Statistics

Cronbach's Alpha	N of Items
.777	14

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
App can guide me to give responses while using it	42.31	45.218	.438	.761
It is easy to predict faults from this app	42.86	46.613	.263	.777
I can easily tell if the system is getting faulty	43.18	47.369	.217	.780
App has faulty message pop ups	43.05	44.242	.413	.762
Icons are not confusing	42.75	46.094	.373	.766
Symbols and icons are a clear guidance for app navigation	42.41	45.806	.468	.760
System feedback can guide subsequent actions	42.57	44.785	.407	.763
System guidelines are available for next actions of using app	42.61	45.069	.443	.760
Pop up messages of App offer guide to user	42.80	44.384	.502	.755
System had options for auto correction and prompts	42.83	43.118	.600	.746
Actions are prompted by short notes/hypertexts	42.87	44.580	.446	.759
System attracts user attention	42.59	45.879	.301	.773
System can be used smoothly without problems	42.55	46.079	.310	.772
As I intend to lose focus, the system has hints to guide me back	42.63	44.432	.385	.765

Table 6: Participatory Action Learning Measures

Reliability Statistics				
Cronbach's Alpha	N of Items			
.690	10			

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
I gained a lot of knowledge during problem discovery	36.73	12.900	.476	.647
My knowledge and technology appreciation was from problem definition and scoping	36.70	12.453	.506	.638
The use of group discussion was most interesting on my side	36.60	12.605	.396	.658
I mostly enjoyed use of role plays and action demos	36.50	14.301	.187	.693
Use of paper demonstrations was my most learning activity	36.62	12.528	.353	.669
I liked use of cartoons and stick pictures for persona	36.80	12.934	.361	.665
Cartoons and stick pictures were of most interest to me to know about computer application use	36.86	12.534	.377	.663
Text drawings were well used and appealing to me	36.71	12.857	.343	.669
Real hands-on computer practice for app design made me like computer use most	36.17	14.478	.273	.681
I would like to be part of this design exercise if there was opportunity	36.11	14.579	.246	.684

The results imply that the 28 design team members had an observation consistence of 84.4% for perception variable, 77.7% for projection, 75.8% for comprehension and 69% for participatory action learning from the simulation process. De Wit, Heerwegh and Verhoeven (2014) used a similar construct reliability methodology in their study to examine whether openness for ICT and scientific research predict ICT skills and ICT use among bachelor students. Meanwhile, the use of item analysis yields improved results, in terms of examining the mechanisms influencing a given phenomenon in a given context, even though the Cronbach's alpha value (reliability) decreases (Pather & Uys, 2008).

The results further reveal that co-design team members gained knowledge during the participatory design process. Examining extent to which Participatory Action Learning (tacit and explicit) was influenced by situation awareness criteria was through ordinary least squares regression results presented below.

4.3 Ordinary Least Squares Regression Results

From the descriptive results, items that constitute a given construct (the three situation awareness constructs) were aggregated into a composite measure and ordinary least squares were used to examine the explanatory power of the outcome as a statistical theoretical lens. Examining extent to which Participatory Action Learning (tacit and explicit) was influenced by cognitive criteria was through ordinary least squares and the model summary is presented in table below.

Table 7: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig.
1	.483 ^a	.233	.204	.34057	.000

a. Predictors: (Constant), Projection, Perception, Comprehension

From the model summary in Table 47 above, it is evident that 23.3% of variations in participatory action learning among co-design team members are influenced by the three cognitive information-processing criteria. There are still 76.7% of factors that could influence action user decision like usability and intention for use. Such factors and constructs are candidate issues for investigation during the participatory usability simulation design process with the typical citizens reported in the subsequent chapter. Archer *et al.* (2013: 328) argue that the R² (if given further explanatory power like “accounted for”, “had an influence”, “effects” and “is due to”) connotes casual efficacy in the realists’ sense, implying that causes bring about their effects. Moreover, such results point to hidden regularities that are not observed directly in an open system (Ron, 2002). Similarly, the error term results indicate that the mechanisms of relationship between the situation awareness constructs and the anticipated outcome is not perfectly linear as is always the case for social science studies. Some other mechanisms come into play.

Theoretical Modeling using the Regression Results (effect of Mechanisms on Outcome)

After establishing the coefficient of determination, the researcher used statistical inference to investigate the causal mechanisms during the participatory design process using regression coefficients and path modeling. Below are the results of the theoretical model in table 48.

Table 8: Regression Tests from the Empathetic Artifact Prototype Evaluation

Dependent Variable	R ²	Independent Variable	S.E. (b)	B (Standardized Coefficients)	t-statistic	Significant Level
Perception	0.158	Constant			-.001	0.999
		App (Artifact)	1.028	0.397	3.923	0.000**
Comprehension	0.031	Constant			1.439	0.154
		App	1.103	0.177	1.624	0.108
Projection	0.049	Constant			1.164	0.248
		App	1.087	0.222	2.050	0.044**
PAL	0.146	Constant			13.798	0.000
		Perception	0.369	0.382	3.746	0.000**
PAL	0.097	Constant			11.448	0.000
		Comprehension	0.380	0.312	2.973	0.004**
PAL	0.203	Constant			12.132	0.000
		Projection	0.343	0.450	4.536	0.000**
Adopt		Perception	Not tested for in this thesis			
Adopt		Projection	Not tested for in this thesis			
Adopt		PAL	Not tested for in this thesis			

The statistical significance of the model relationships can be tested using β values, the coefficient of determination (R²), t-statistics or significant level values. However, the scientist undertaking a study using this model is at liberty to use the context variables as an explicit or implicit *ceteris paribus* condition and can generate other causal relationships as dictated by the context of design and artifact evaluation. The results path model is presented below in figure 3 using the standardized coefficients and their respective significant values since the independent variables have different measures:

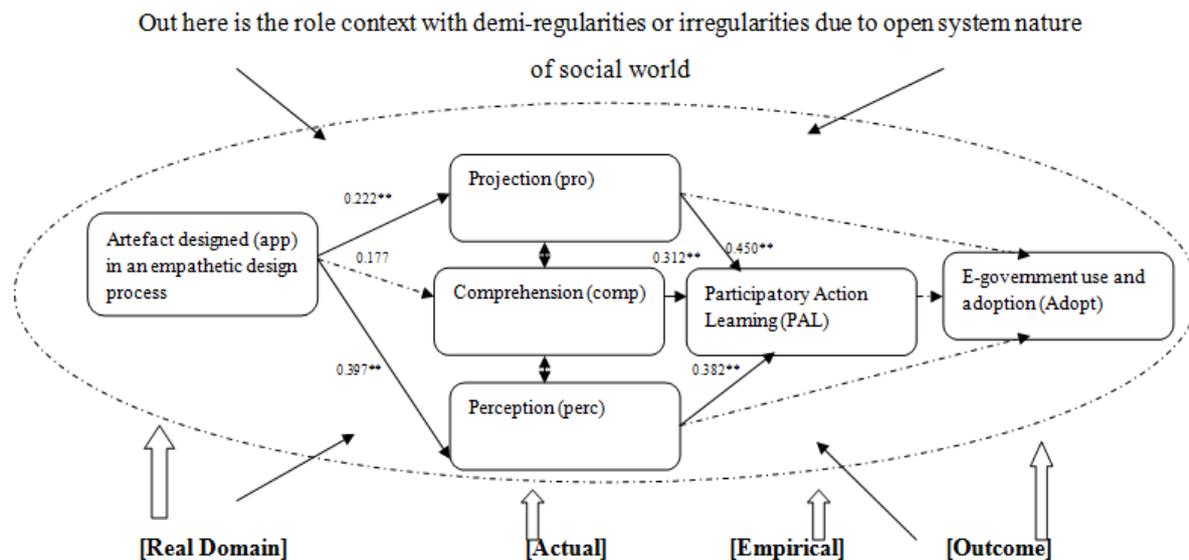


Figure 2: Theoretical Artifact Evaluation Path Model Results

The above model depicts how the designed e-government applications during an empathetic participatory design generate causal mechanisms and how these can be well explained by statistical inference to determine outcomes. Single-headed arrows represent directional causal mechanism relationships while double-headed arrows represent bi-directional casual mechanisms relationship. From the model, the real domain has the artifact that is co-designed. Here, there are mechanisms and structures with enduring properties. These influence the actual domain with events and non-events that are generated by the mechanisms. Such mechanisms include perception, comprehension and projection, all influencing each other iteratively to bring an effect in the empirical domain where events are actually perceived (observed and experienced). This is where decisions and actions as influenced by perception, comprehension and projection are observed and experienced. This results into the outcome in the short run and impact in the long run from any artefacts within a given design context. However, out of the quasi-closure, are demi-regularities and regularities that may influence the mechanisms within the assumed closed context (Finch & McMaster, 2000).

From the results, the co-designed artifact features have a causal-mechanism relationship to how they are perceived (sig.=0.397) and projected (sig.=0.222); with no significant causal relationship as to how they are understood (sig.=0.177). There is a significant causal interrelationship among the situation awareness constructs as observed from the results. Moreover, there is a significant causal relationship between perception and action (sig.=0.382), comprehension and action (sig.=0.312) and projection and action (sig.=0.450). The relationship between situation awareness constructs, PAL and e-government adoption are not tested in this study.

Figure 3 assumes a closed system during the empathetic design process that is not the case in practical environments. The upcoming chapter presents results from the citizen user experiences while simulating the designed artifacts in an open design environment. These were to corroborate the empathetic participants' artifact evaluation criteria while revealing other usability issues termed as context issues operating within an open systems design space.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The first contribution this study makes is to advance an artefact evaluation criterion during and after the artefact has been designed. This paper shades light to the design scientists and philosophers of science who have mixed and differing views about attention given to the logic of evaluating participatory design research processes and outcomes. We make a contribution by observing that knowing relevant mechanisms is necessary for statistical inference and estimates are important to understand the process by which something has been brought about. Under causal inference, the focus is not on relationships between variables, but on the triggers, actors, their relationships and the intended and unintended outcomes of their actions, under this case, researchers, system designers and system users. To that note, casual inference is an inference mode in which events are explained by postulating (and identifying) mechanisms which are capable of producing them.

Moreover, to the scientific space, we join other authors who have advocated for the need for a modified ontological position from the philosophically pure case of an open system, to one which suggests that in social systems, individual and institutional experiments exist by use of what they term as quasi-closure. We argue that quasi-closure can provide leverage for researchers seeking to validate and generalize empirical insights about social processes and that the nature of what is potentially a completely open system is modified as a direct consequence of human action. In fact, this study too, emphasizes the need to use statistical modeling and call upon the many of the epistemological pronouncements of critical realism who are still suspicious of statistical methods to employ them in estimating the causal mechanisms. This is because statistical modeling can offer an explanatory power to causal inference through a retroductive process.

We therefore render support to Downward and Mearman (2002) and several other similar researchers who guide that drawing upon statistical modeling, a useful symbiosis of ideas is produced which has positive implications for the practice of critical-realist empirical work in efforts to examine mechanisms under play. From literature, whereas there are arguments for the call statistical modeling, mixed methods and multi methods that encompass statistical as well, there are barely papers published with such empirical data while taking a critical realist's view. This study concludes that whereas there exists opposition by dominant critical realist theorists to statistical analysis, we argue that statistical inference can be used as a measure to further strengthen the need for exploration of other mechanisms that fail to explain the casual model. This paper affirms the importance of falsification and verification efforts for progress in theory development.

5.1 Recommendations

In terms of areas for further research, critical realism is a philosophy of science that is open to practical application through reference to any individual scientific theories and use of any individual research methods, which can be combined in order to reveal causal mechanisms and causal contexts (Mingers, 2004; Fox & Do, 2013). Therefore, with advancement of science of artificial innovations and whereas data/big data has become a buzz word yet real, critical realist researchers should contribute to the information value chain through more design science, data science and data analytics to make predictions about complex phenomena with available big data sources. Such predictive models could then be validated or falsified with action-based research from the organization contexts from which it was captured since that is the true agenda of critical realism research as aimed at bridging the extremists on one hand who argue that there are universal mechanisms of causation and on the other that there are not any

generalizable mechanisms of causation in human endeavors. Within critical realism, as within the real world of technology implementations, bringing about an effect from a cause is dependent upon both causal mechanism and causal context, that could be well established with multi-methods, especially when there is availability of big or open data.

Moreover, this was an empathetic participatory design paper with no input of views of IS consultants, managers, business IS developers and the framework could be verified or falsified within those contexts in yet another study.

REFERENCES

- Archer, M., Bhaskar, R., Collier, A., Lawson, T. and Norrie, A., 2013. *Critical realism: Essential readings*. Routledge.
- Astbury, B. and Leeuw, F.L., 2010. Unpacking black boxes: mechanisms and theory building in evaluation. *American journal of evaluation*, 31(3), pp.363-381.
- Baert, P., 1996. Realist philosophy of the social sciences and economics: a critique. *Cambridge Journal of Economics*, 20(5), pp.513-522.
- Baskerville, R., 2008. What design science is not, *European Journal of Information Systems*, 17:5, 441-443, DOI: 10.1057/ejis.2008.45
- Bedny, G. and Meister, D., 1999. Theory of activity and situation awareness. *International Journal of cognitive ergonomics*, 3(1), pp.63-72.
- Bhaskar, R. (1978). On the possibility of social scientific knowledge and the limits of naturalism. *Journal for the Theory of social Behaviour*.
- Bhaskar, R. and Danermark, B., 2006. Metatheory, interdisciplinarity and disability research: a critical realist perspective. *Scandinavian Journal of Disability Research*, 8(4), pp.278-297.
- Bhaskar, R., 1975. Feyerabend and bachelard: two philosophies of science. *New Left Review*, 94(3), pp.31-55.
- Bhaskar, R., 2014. *The possibility of naturalism: A philosophical critique of the contemporary human sciences*. Routledge.
- Biesbroek, G.R., Termeer, C.J., Klostermann, J.E. and Kabat, P., 2014. Rethinking barriers to adaptation: Mechanism-based explanation of impasses in the governance of an innovative adaptation measure. *Global Environmental Change*, 26, pp.108-118.
- Bisman, J., 2010. Postpositivism and accounting research: A (personal) primer on critical realism. *Australasian Accounting, Business and Finance Journal*, 4(4), pp.3-25.
- Bloch, P.H. 1981. An exploration into the scaling of consumers' involvement with a product class. *Advances in Consumer Research* Volume 8: 61-65.
- Bovill, C. & Bulley, C.J. 2011. A model of active student participation in curriculum design: exploring desirability and possibility. In C. Rust (Ed.), *Improving student learning* (pp. 176-188). Oxford: The Oxford Center for Staff and Learning Development.
- Bovill, C., Bulley, C.J. & Morss, K. 2011. Engaging and empowering first-year students through curriculum design: perspectives from the literature. *Teaching in Higher Education*, 16(2): 197-209.
- Burton-Jones, A. and Straub, D.W., 2004. Minimizing method variance in measures of system usage. *Proceedings of the Southern Association for Information Systems (SAIS)*, pp.336-342.
- Carlsson, S.A., 2006. Design science research in Information Systems: a critical realist perspective. *ACIS 2006 Proceedings*, p.40.
- Carolan, M.S., 2005. Society, biology, and ecology: Bringing nature back into sociology's disciplinary narrative through critical realism. *Organization & Environment*, 18(4), pp.393-421.

- Cicmil, S., Williams, T., Thomas, J., & Hodgson, D. (2006). *Rethinking Project Management: Researching the actuality of projects*. International Journal of Project Management, 24(8), 675–686.
- Davis, F.D., 1985. *A technology acceptance model for empirically testing new end-user information systems: Theory and results* (Doctoral dissertation, Massachusetts Institute of Technology).
- De Wit K, Heerwegh D, Verhoeven JC. Can openness to ICT and scientific research predict the ICT skills and ICT use of bachelor's students? *Computers & Education*. 2014 Sep 1;78:397-413.
- Downward, P. and Mearman, A., 2002. Critical realism and econometrics: constructive dialogue with Post Keynesian economics. *Metroeconomica*, 53(4), pp.391-415.
- Downward, P. and Mearman, A., 2005. Critical realism and econometrics: interaction between philosophy and post Keynesian practice. In *Applied Economics and the Critical Realist Critique* (pp. 123-140). Routledge.
- Downward, P., 2016. 10 Regression analysis: a review. *Handbook of research methods and applications in heterodox economics*, p.210.
- Downward, P., Finch, J.H. and Ramsay, J., 2002. Critical realism, empirical methods and inference: a critical discussion. *Cambridge journal of economics*, 26(4), pp.481-500.
- Druin, A. & Fast, C. 2002. The child as learner, critic, inventor, and technology design partner: An analysis of three years of Swedish student journals. *International Journal of Technology and Design Education*, 12(3): 189-213.
- Druin, A. 2010. Children as codesigners of new technologies: Valuing the imagination to transform what is possible. *New Directions for Youth Development*, 2010 (128): 35-43.
- Ellis, R.D. and Kurniawan, S.H., 2000. Increasing the usability of online information for older users: A case study in participatory design. *International Journal of Human-Computer Interaction*, 12(2), pp.263-276.
- Elsenbroich, C., 2012. Explanation in agent-based modelling: Functions, causality or mechanisms?. *JASSS*, 15(3).
- Endsley, M.R., 1995. Measurement of situation awareness in dynamic systems. *Human factors*, 37(1), pp.65-84.
- Endsley, M.R., 2015. Situation awareness: operationally necessary and scientifically grounded. *Cognition, Technology & Work*, 17(2), pp.163-167.
- Finch, J.H. and McMaster, R., 2002. On categorical variables and non-parametric statistical inference in the pursuit of causal explanations. *Cambridge Journal of Economics*, 26(6), pp.753-772.
- Fishbein, M. and Ajzen, I., 1975. *Intention and Behavior: An introduction to theory and research*.
- Fleetwood, S., 2002. Boylan and O'Gorman's causal holism: a critical realist evaluation. *Cambridge Journal of Economics*, 26(1), pp.27-45.
- Fox, S. and Do, T., 2013. Getting real about Big Data: applying critical realism to analyse Big Data hype. *International Journal of Managing Projects in Business*, 6(4), pp.739-760.

- Gregor, S. and Hevner, A.R., 2013. Positioning and presenting design science research for maximum impact. *MIS quarterly*, pp.337-355.
- Hawley, M. 2007. *The Repertory Grid: Eliciting user experience comparisons in the customer's voice*, Accessed at www.uxmatters.com on June, 2017.
- Hedström, P. and Ylikoski, P., 2010. Causal mechanisms in the social sciences. *Annual review of sociology*, 36, pp.49-67.
- Hedström, P., 2008. Studying mechanisms to strengthen causal inferences in quantitative research. *The Oxford handbook of political methodology*, pp.319-335.
- Hensen, J.L. and Lamberts, R. eds., 2012. *Building performance simulation for design and operation*. Routledge.
- Hevner, A. and Chatterjee, S., 2010. Design science research in information systems. In *Design research in information systems* (pp. 9-22). Springer, Boston, MA.
- Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS quarterly*, 75-105.
- Holland, P.W., 1986. Statistics and causal inference. *Journal of the American statistical Association*, 81(396), pp.945-960.
- Iannacci, F. and Hatzaras, K.S., 2012. Unpacking ostensive and performative aspects of organisational routines in the context of monitoring systems: A critical realist approach. *Information and Organization*, 22(1), pp.1-22.
- Imbens, G.W. and Rubin, D.B., 2015. *Causal inference in statistics, social, and biomedical sciences*. Cambridge University Press.
- Ives, B., Olson, M.H. & Baroudi, J.J. 1983. The measurement of user information satisfaction. *Communications of the ACM*, 26(10): 785-793
- Kardong-Edgren, S., Adamson, K.A. and Fitzgerald, C., 2010. A review of currently published evaluation instruments for human patient simulation. *Clinical Simulation in Nursing*, 6(1), pp.e25-e35.
- Kouprie, M. & Visser, F.S. 2009. A framework for empathy in design: stepping into and out of the user's life. *Journal of Engineering Design*, 20(5): 437-448.
- Kyakulumbye, S. (2020). A framework for developing citizen-centric e-government applications in developing countries: The design-reality gap in Uganda.
- Kyakulumbye, S., Pather, S., & Jantjies, M. (2019). Towards design of citizen centric e-government projects in developing country context: the design-reality gap in Uganda.
- Lawani, A. (2021). Critical realism: what you should know and how to apply it. *Qualitative research journal*, 21(3), 320-333.
- Lindsay, S., Brittain, K., Jackson, D., Ladha, C., Ladha, K. & Olivier, P. 2012, May. Empathy, participatory design and people with dementia. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (521-530). ACM.
- McEvoy, P. and Richards, D., 2006. A critical realist rationale for using a combination of quantitative and qualitative methods. *Journal of research in nursing*, 11(1), pp.66-78.
- Meyer, S.B. & Lunnay, B. 2013. The application of abductive and retroductive inference for the design and analysis of theory-driven sociological research. *Sociological Research Online*, 18(1): 1-11.

- Miller, K.D. and Tsang, E.W., 2011. Testing management theories: critical realist philosophy and research methods. *Strategic Management Journal*, 32(2), pp.139-158.
- Mingers, J. 2006. A critique of statistical modelling in management science from a critical realist perspective: its role within multimethodology. *Journal of the Operational Research Society*, 57(2): 202-219.
- Mingers, J., 2004. Real-izing information systems: critical realism as an underpinning philosophy for information systems. *Information and organization*, 14(2), pp.87-103.
- Moore, G.C. & Benbasat, I. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*, 2(3): 192-222.
- Olsson, E. and Jansson, A., 2005. Participatory design with train drivers—a process analysis. *Interacting with Computers*, 17(2), pp.147-166.
- Pather, S. and Uys, C.S., 2008. Using scale reduction techniques for improved quality of survey information. *SA Journal of Information Management*, 10(3).
- Patrick, J., & Morgan, P. L. (2010). Approaches to understanding, analysing and developing situation awareness. *Theoretical Issues in Ergonomics Science*, 11(1-2), 41-57.
- Pawson, R. and Tilley, N., 1997. An introduction to scientific realist evaluation. *Evaluation for the 21st century: A handbook*, pp.405-418.
- Peffers, K., Rothenberger, M., Tuunanen, T., & Vaezi, R. (2012, May). Design science research evaluation. In *International conference on design science research in information systems* (pp. 398-410). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Peirce, C.S., 1957. The logic of abduction. *Peirce's Essays in the Philosophy of Science* ed. by Vincent Thomas, 235-55. New York.
- Pries-Heje, J., Baskerville, R. and Venable, J.R., 2008, June. Strategies for Design Science Research Evaluation. In *ECIS* (pp. 255-266).
- Roberts, J. M. (2014). Critical realism, dialectics, and qualitative research methods. *Journal for the theory of social behaviour*, 44(1), 1-23.
- Rogers, P.J. and Weiss, C.H., 2007. Theory-based evaluation: Reflections ten years on: Theory-based evaluation: Past, present, and future. *New directions for evaluation*, 2007(114), pp.63-81.
- Ron, A., 2002. Regression analysis and the philosophy of social science: A critical realist view. *Journal of Critical Realism*, 1(1), pp.119-142.
- Rosli, D., 2015. Cognitive awareness prototype development on user interface design. *TOJET: The Turkish Online Journal of Educational Technology*, 4(2), pp.32-40.
- Sanders, E.B.N., 2003. From user-centered to participatory design approaches. In *Design and the Social Sciences* (18-25). CRC Press.
- Sayer, A., 1992. *Method in social science: A realist approach*. Psychology Press.
- Seo, S.D., 2016. A study on interaction-driven comparison between analog and digital gaming control interface on smartphone.
- Smith, M.L., 2006. Overcoming theory-practice inconsistencies: Critical realism and information systems research. *Information and organization*, 16(3), pp.191-211.

- Soros, G., 2013. Fallibility, reflexivity, and the human uncertainty principle. *Journal of Economic Methodology*, 20(4), pp.309-329.
- Srinivasan, A. 1985. Alternative measures of system effectiveness: associations and implications. *MIS Quarterly*, 243-253.
- Streiner, D.L. 2003. Starting at the beginning: an introduction to coefficient alpha and internal consistency. *Journal of Personality Assessment*, 80(1): 99-103.
- Thomas, T., Singh, L. and Gaffar, K., 2013. The utility of the UTAUT model in explaining mobile learning adoption in higher education in Guyana. *International Journal of Education and Development using ICT*, 9(3).
- Todd, P. & Benbasat, I. 1992. The use of information in decision-making: an experimental investigation of the impact of computer-based decision aids. *Mis Quarterly*, 373-393.
- Tsang, E.W. and Kwan, K.M., 1999. Replication and theory development in organizational science: A critical realist perspective. *Academy of Management review*, 24(4), pp.759-780.
- Tsang, E.W., 2014. Case studies and generalization in information systems research: A critical realist perspective. *The Journal of Strategic Information Systems*, 23(2), pp.174-186.
- Tuunanen, T., Winter, R., & Brocke, J. V. (2024). Dealing with complexity in design science research: A methodology using design echelons. *MIS quarterly*, 48(2), 427-458.
- Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D., 2003. User acceptance of information technology: Toward a unified view. *MIS quarterly*, pp.425-478.
- Venkatesh, V., Thong, J.Y., Chan, F.K., Hu, P.J.H. & Brown, S.A. 2011. Extending the two-stage information systems continuance model: Incorporating UTAUT predictors and the role of context. *Information Systems Journal*, 21(6): 527-555.
- Wright, M.C., Taekman, J.M. and Endsley, M.R., 2004. Objective measures of situation awareness in a simulated medical environment. *BMJ Quality & Safety*, 13(suppl 1), pp.i65-i71.
- Wynn Jr, D. and Williams, C.K., 2012. Principles for conducting critical realist case study research in information systems. *MIS quarterly*, pp.787-810.
- Zachariadis, M., Scott, S. and Barrett, M., 2013. Methodological implications of critical realism for mixed-methods research. *MIS quarterly*, pp.855-879.

Acknowledgments and Conflicts of Interest Declaration.

The National Research Foundation of South Africa, which during the time of research partially funded the study is acknowledge. This study and the authors listed have no conflict of interest.

License

Copyright (c) 2026 Stephen Kyakulumbye, Anny Katabaazi Bwengye, Shaun Pather



This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

Authors retain copyright and grant the journal right of first publication with the work simultaneously licensed under a [Creative Commons Attribution \(CC-BY\) 4.0 License](https://creativecommons.org/licenses/by/4.0/) that allows others to share the work with an acknowledgment of the work's authorship and initial publication in this journal.