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THE APPLICATION OF FMA TO AUTOMATION RESEARCH

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Abstract

Process automation is a field of study which is rapidly emerging due to it's rate of adoption across the world. With the rapid adoption rate, more research energy is being focused within the automation space. Due to the challenges that process automation aims to solve, the use of soft systems methodology (SSM), which focuses on understanding a problem situation, is a suitable approach to understanding the environment in which automation is being researched. Along with SSM, the FMA model (which helps researchers identify area of interest, methodology and framework of ideas) can be generalised enough to be used as a methodology within any automation-orientated research.

1. Introduction

The Fourth Industrial Revolution is an emerging chapter in human development that potentially represents a fundamental change in our lives (World Economic Forum, 2020). The World Economic Forum (2020) goes on to suggest that the Fourth Industrial Revolution could utilise the opportunity to look beyond technology and find ways to give people the opportunity to positively impact society.

Acemoglu and Restrepo (2019) define automation as the use of technology to enable substituting capital for human labour, which is supported by Smith and Fressoli (2021), who expand on this by proposing automation as a supporting element of the 4IR. Groover (2019) highlights that the first forms of automation were present during the time of mechanical clocks in the 1330s. Software was introduced into automation between the 1960s and 1970s when automation was focused on integrated circuits and computer-integrated manufacturing. Although the concept of automation is not new, the implementation and research of automation within the information systems environments are still evolving (Groover, 2019).

Soft systems methodology (SSM) is an approach which attempts to use business process modelling to understand a problem situation (Checkland & Poulter, 2020). The context of Information Systems is described by Checkland and Holwell (1993) as being centrally concerned with how humans create meaning through relative experiences using mature and fundamental SSM concepts. Checkland (1985) proposed the FMA model as a systemic thinking model, as part of SSM, which could be used to better understand and execute automation-orientated research.

1.1 Background

The context of the automation research in discussion, as proposed by Muller (2022), specifically focuses on the comparison between digital process automation capabilities (DPA) and human capabilities in terms of time, cost and scope to understand which underlying (or secondary) factors influence the triple constraint model, as outlined in Figure 1-1.

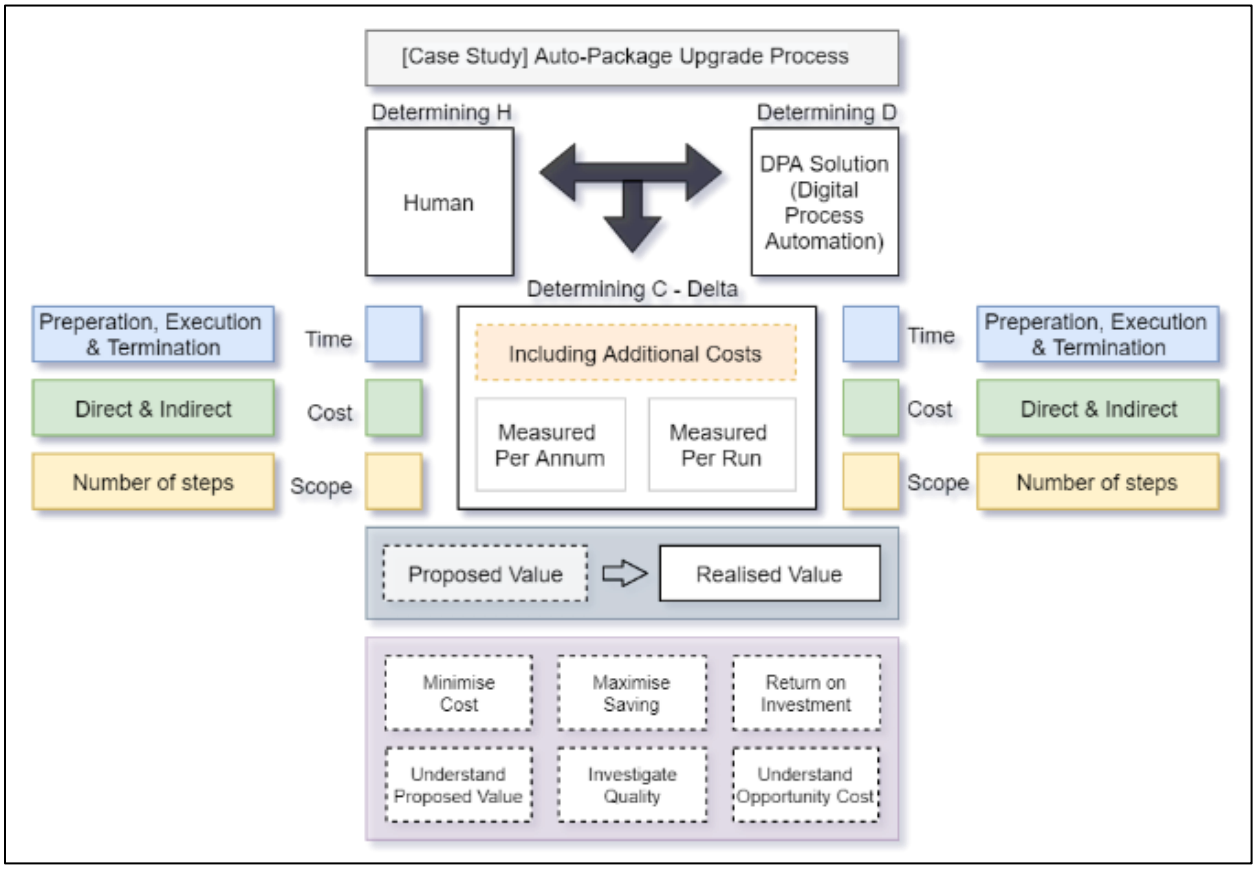

Figure 1-1: Case Study Overview (Muller, 2022)

As seen in Figure 1-1, the comparison of human capability versus DPA capability within a case study environment, focused on the triple constraint model factors (time, cost and scope) and how each constraint is influenced by supporting factors:

- **Time Constraint:** Time (or process duration) can be divided into multiple categories which best describe the intervals or frequency at which process steps should be evaluated. The case study environment referenced in Figure 1-1 divides the phases in which time should be measured into the following phases:
  - **Preparation Phase**: The initialisation and preparation of the environment before the process steps are executed.
  - **Execution Phase:** The execution of process steps within the prepared environment.
  - **Termination Phase:** The conclusion, clean up and artefact disposal once the process steps have been executed.
- **Cost Constraint:** Cost can be broken down in much more granular detail but on a higher level, the division of cost is mainly into two categories:

  - **Direct Cost:** Any financial implications that are directly incurred by the process (examples include development, execution cost, etc.)
  - **Indirect Cost:** Any financial implications that support the inner workings of the process but are not directly incurred by the process (an example is licensing or infrastructure).
- **Scope Constraint:** Scope can be evaluated, not only through the number of process steps, but also through the assured quality and consistency of process execution.

The evaluation of the abovementioned metrics creates multiple questions, some of which provide an undertone of comparing proposed (or estimated) value as compared to the actual, realised value of implementing an automation solution, with the appropriate level of adoption by business users.

2. Research Design

According to Saunders et al. (2012), a research philosophy organises the development of knowledge in a particular field of study. The research onion presented by Saunders et al. (2012) proposes that there are mainly four different research philosophy approaches, namely positivism, realism, interpretivism and pragmatism, which have been amended in Figure 2-1 to represent the position of this study. The sections that follow further elaborate on the research onion elements as well as how they are to be applied to this study.

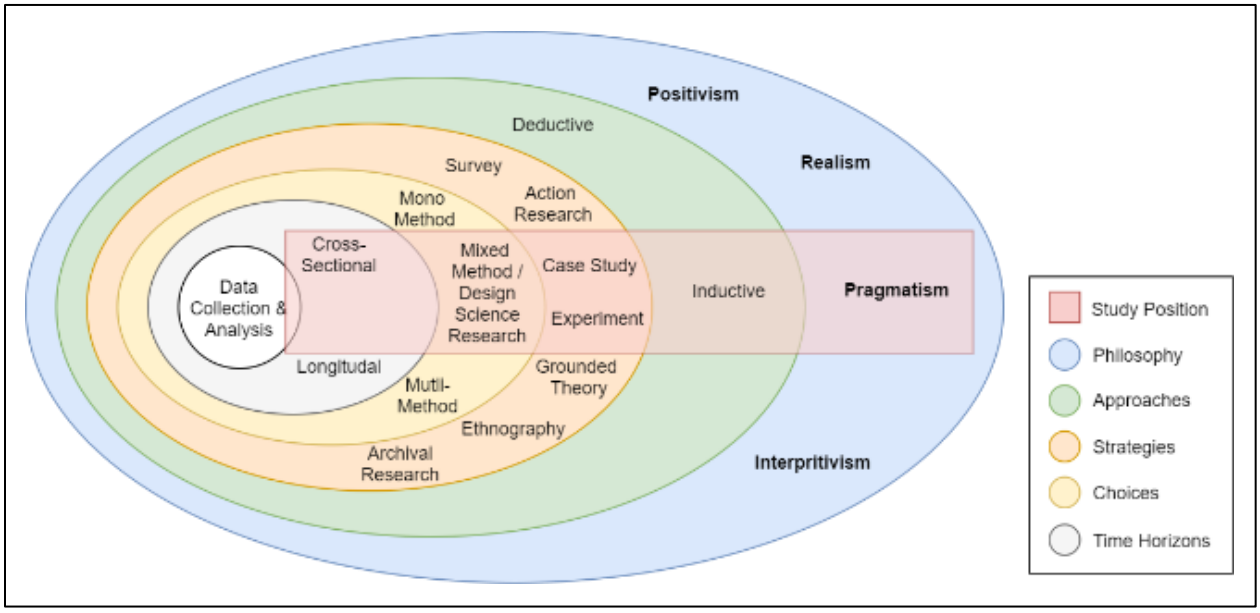

Figure 2-1: The research onion, adapted from Saunders et al. (2012)

The pragmatism philosophy references what some might consider an unrealistic approach in practice which avoids the debates on reality or truth as the focus would rather be placed on what is deemed valuable by the researcher (Gunesh, 2016). The importance of the pragmatic philosophy is the practical consequence of the study. Saunders *et al.* (2012) suggest that there may be multiple realities with different outcomes rather than the perception is that there is only one point of view, which is supported by Creswell and Clark (2017) as well as Gunesh (2016).

A research approach can either be inductive or deductive in nature (Saunders et al., 2012). The difference is the direction of flow between generalised principles and a specific conclusion. Perdicoúlis and Glasson (2006) suggests that deductive reasoning moves from generalised principles to a specific conclusion while Thomas (2003) proposes that inductive reasoning moves in the opposite direction, from specific principles towards a generalised conclusion. The study in question was performed within a case study environment with specific standards, objectives and a brief from which a conclusion was drawn, this research therefor, followed an inductive approach as the reasoning converged from a specific instance to a generalisable conclusion.

A research strategy is the plan for conducting research which guides a researcher with planning, executing and monitoring a study (Johannesson & Perjons, 2014). As seen in Figure 2-1, this study is positioned as experiments within a case study, which design science research has close ties to, within the research strategies ring of the research onion. Experiments are referred to as the collection of primary data through observing individual decision-making or interactive tasks (Croson *et al.*, 2007). Case study research is used to study a range of purposes and topics that contain the necessary variables and problems that the study is focused on understanding or solving (Harrison *et al.*, 2017). Due to the research being executed within a case study environment, the research was subject to the governance and standards of the environment. The case study organisation adopted the scaled agile framework (SAFe) as a project management methodology which dictated that the study conform to the principles of SAFe, in addition to the academic research methodology.

Iyawa et al. (2016) define design science research (DSR) as a methodology that focuses on creating new knowledge with the purpose of changing existing situations into preferred situations. The intention of using DSR, as suggested by Lukka (2003), is to solve real-life problems by making a contribution to the applied theory presented throughout the conducted research. Hevner (2007) strongly supports the use of DSR to introduce new knowledge through the invention and innovation of theories and artefacts, executed in three cycles, namely relevance, design and rigour. The model proposed by Hevner et al. (2004) was been amended, as seen in Figure 2-2, to represent the position and layout that the study followed.

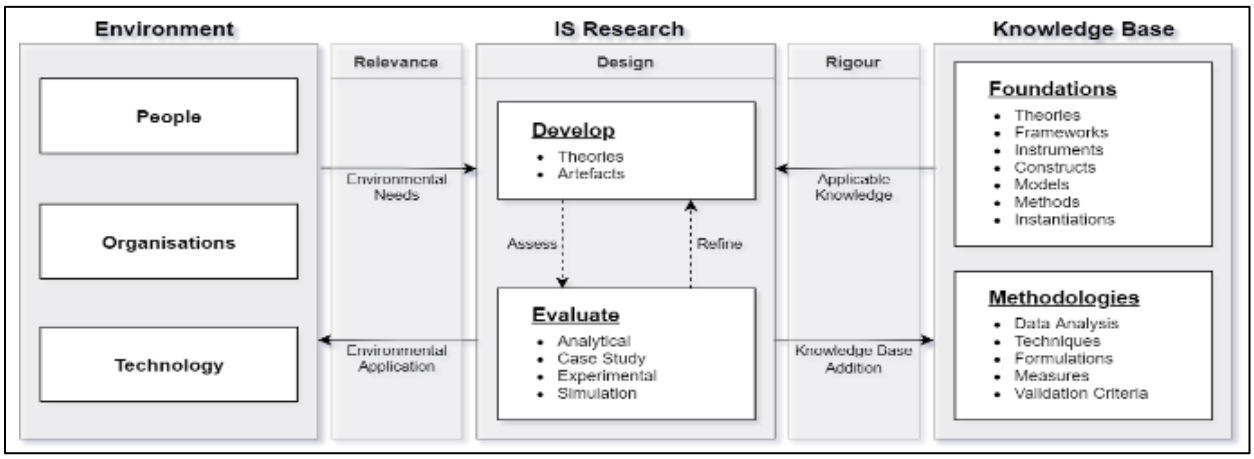

Figure 2-2: Design science research within the context of this study

Figure 2-2 illustrates how the development of theories and artefacts will take in all environmental needs and requirements as inputs, utilising any applicable knowledge from the available knowledge base. The iterative design cycles will be evaluated in each iteration, while outputting the environmental application and knowledge base additions to the environment and knowledge base, respectively. The relevance cycle

will represent the flow of all environmental needs and environmental application between the environment and the information system (IS) research. The rigour cycle will represent the flow of knowledge between the knowledge base and the IS research.

Gerber et al. (2015) propose a research lens of using DSR as an approach. The purpose of the lens is to identify the motivation for use, the research design followed, the artefact produced and the user experience. The research lens is built on the foundation of the model proposed by Kuechler and Vaishnavi (2008), which illustrates the different process steps within DSR (along with the outcomes for each step) as well as how each step contributes to the knowledge base. This model was amended (as seen in Figure 2-3) to depict the additions to the knowledge base from the research done by Muller (2022).

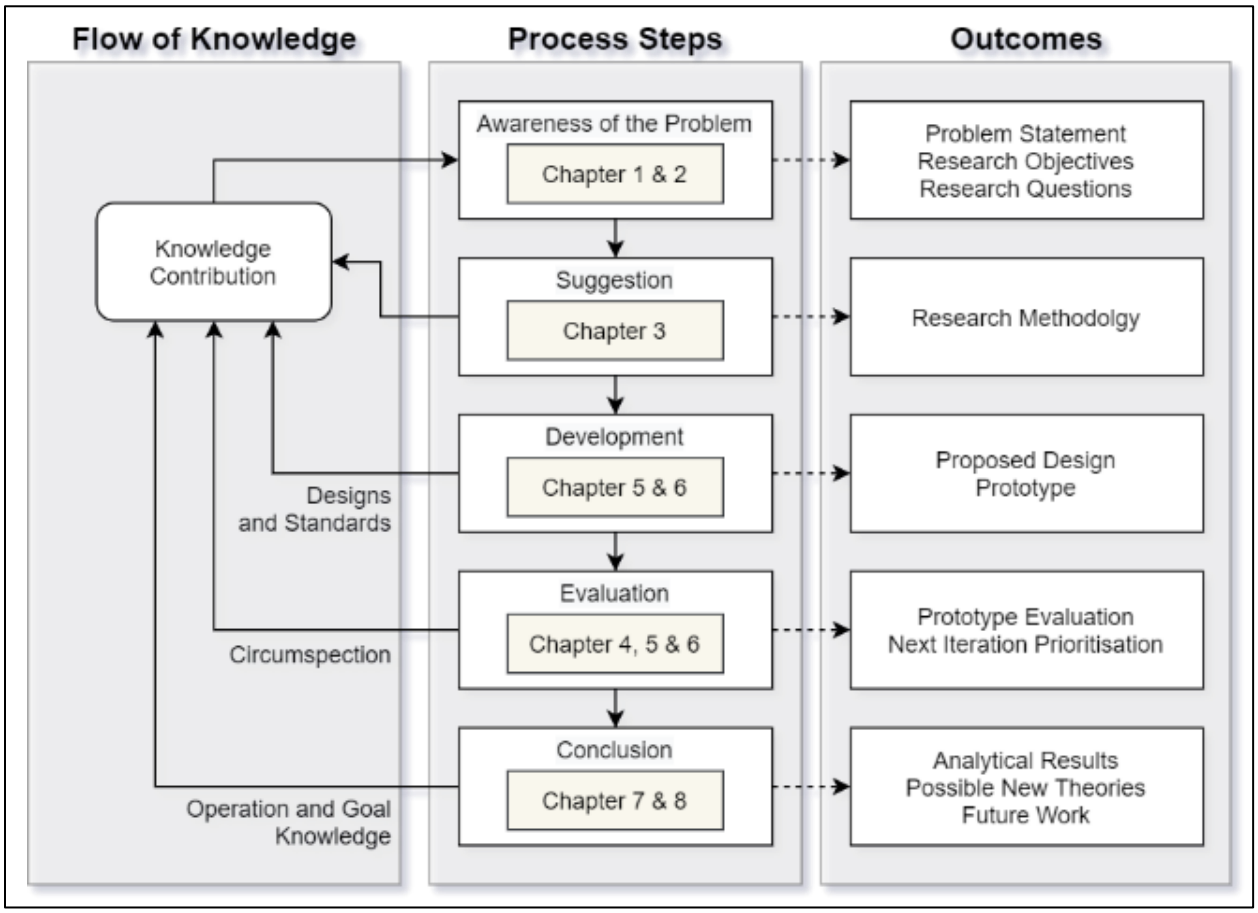

Figure 2-3: Design science research knowledge contributions

4. Analysis and Discussion

Checkland (1985) proposed the FMA model as a systemic thinking model that can be used for 'any piece of research' with the aim of fostering a researcher's understanding and representation of their research through solidifying the framework of their ideas (F) which is built upon their methodology (M) and interacts with some area of concern, interest or application (A). Researchers use the core principles of this model to represent their research across multiple disciplines. This is evident in multiple examples which include but are not limited to, the use of FMA as the representation of the research conducted by Fonseca and Carnicelli

(2021) which focuses on corporate social responsibility and sustainability in a hospitality family business, as opposed to the manner in which Venter (2019) made use of the model to represent the elicitation of business intelligence business requirements, using a critical systems approach.

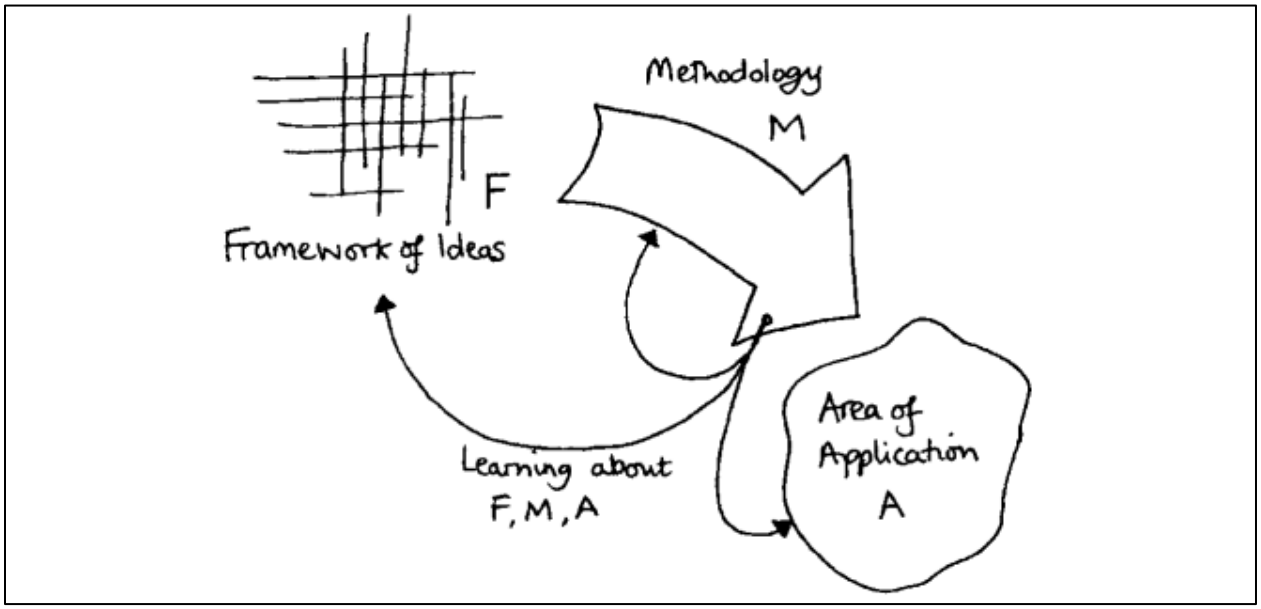

Figure 4-1 The FMA Model (Checkland, 1985)

The context provided in Figure 1-1 and Figure 4-1 are collectively represented by the amendment of the FMA model proposed by Checkland (1985) with specific reference to the research presented by Muller (2022) in Figure 4-2.

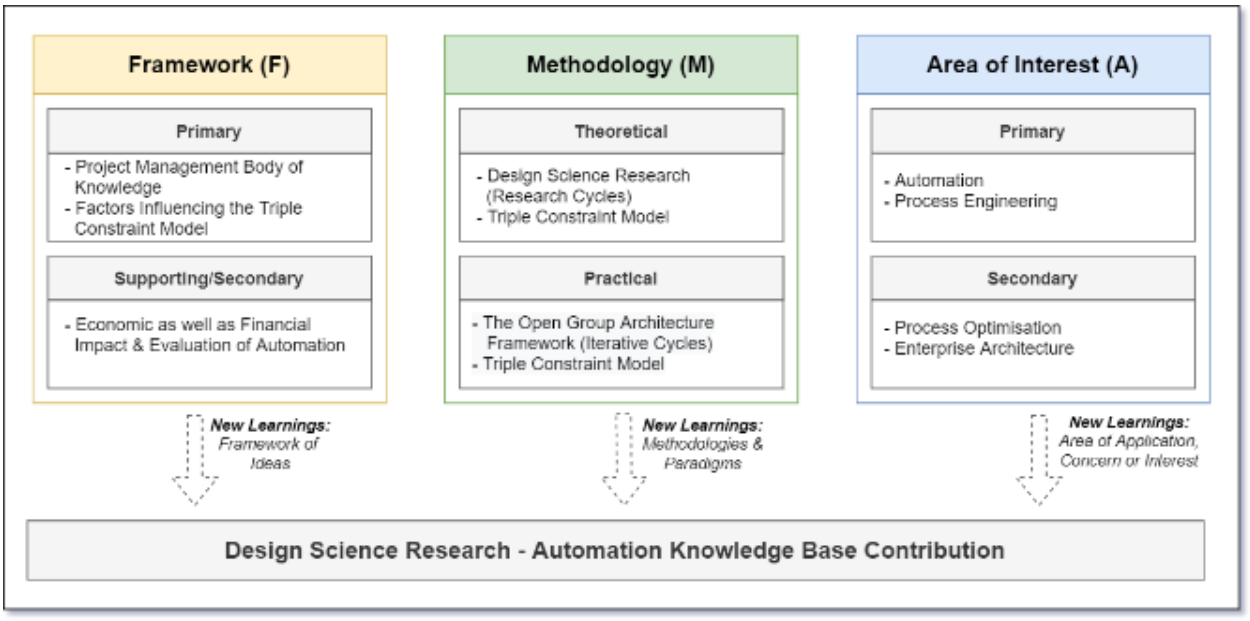

Figure 4-2: The FMA Representation of Automation Research done by Muller (2022)

Figure 4-2 represents the initial composition of the study done by Muller (2022) as the first iteration and can be obfuscated further by removing the details specific to the study which proposes a generalised

methodology of conducting research about automation using FMA. The use of FMA as a methodology in automation research would be comprised of all components outlines in Figure 4-3 which represents the next iteration of the refined FMA model, generalised for automation research.

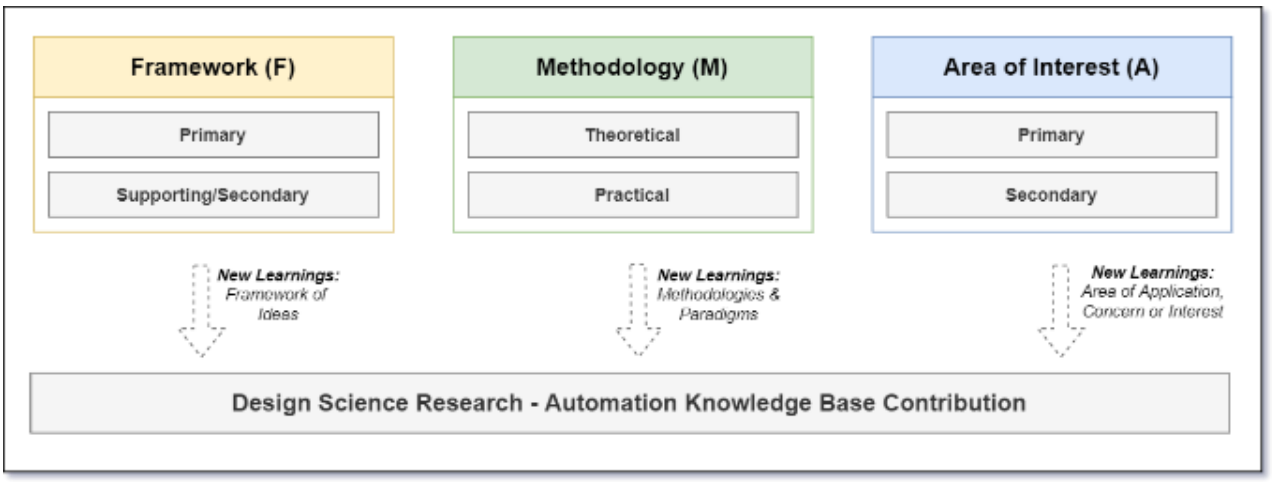

Figure 4-3: The High-Level FMA Representation of Automation Research

As seen in Figure 4-3, the framework of ideas, methodology and area of interest can be broken up further to identify the FMA (as a methodology) of a study. In order to use the FMA model as a methodology, the research would first need to identify the area of interest which can be broken up into the following:

- **Primary Area of Interest:** The primary area of interest in automation research would be automation, else it would not be considered automation research. This can also be coupled with data as the two go hand-in-hand. Depending on the type of automation that occurs within the research and the perspective from which it is being researched, process engineering and optimisation may also feature as primary or secondary areas of interest.
- **Secondary Area of Interest:** The secondary area of interest in automation research would be specific to the environment or industry in which the research is taking place. In cases where the research is executed within a case study environment, the area of interest would be subject to the specific interests that exist within the environment, motivating the validity and cause for the research.

Once the researcher has appropriately identified the are of interest, in entirety, the next step would be to fully define the methodology. A methodology will always have a theoretical component but it may not always have a practical component as that would depend on the nature of the research. Defining the methodology may be broken in more detail:

- **Theoretical Methodology:** The theoretical component of the methodology would aim to address the research philosophy (pragmatism, positivism, interpretivism, realism, etc.) as well as the choice of method (mono-method, mixed method or multi-method) to be used throughout the study. The time horizon (longitude or cross-sectional) should also be considered and addressed as part of the theoretical component of the methodology as it lays the foundation of the research plan. Any other theoretical models or instruments that are used as part of the study would also be introduced within this section.
- **Practical Methodology:** In cases where artefacts are to be developed as part of the research, a framework would need to be identified and detailed. In most cases, DSR would most likely be a prominent feature of the research, in which case the research cycles and knowledge contribution would

be best detailed as part of the theoretical methodology while the practical implementation is recorded as part of the practical methodology.

The last step would be to identify the framework of ideas that would be formed as an output from the conclusion of the study. The framework of ideas would be where the researcher would deviate from the idea of 'what fits into the box'. Ideally, the framework of ideas would be broken down by the research approach and the domain:

- **Primary Framework of Ideas**: The research approach is either inductive or deductive in nature, meaning that research either stems from specific principles and leads to a generalised conclusion or a specific conclusion is used to identify generalised principles. The primary framework of ideas may be based upon the foundation of what the input and output of the research is and how it is transformed, for example – how the findings from a case study may be generalised and applied outside of the case study environment.
- **Secondary Framework of Ideas**: The secondary framework of ideas may be attributed to domains that support the contribution of research towards the framework of ideas, possibly through how the domain may be impacted, for example. A more practical example may be the economic or psychological impact of the automation research.

Based on the above, Figure 4-3 can be further broken down to encapsulate all layers of the research onion presented by Saunders *et al.* (2012), as seen in Figure 4-4 which represents another iteration with further refinement to the FMA model for automation research.

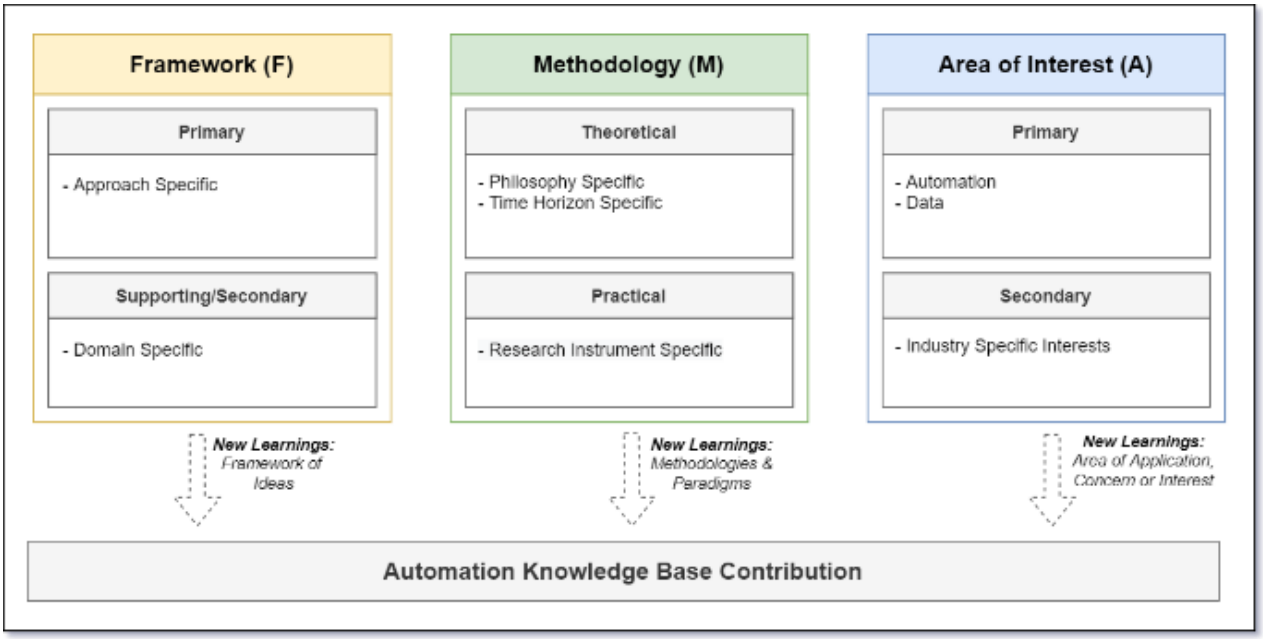

Figure 4-4: The Lower-Level FMA Representation of Automation Research

As seen in Figure 4-4, all three pillars of the model (area of interest, methodology and framework of ideas) contribute to the automation knowledge base. Due to the contributing factor of automation research, it may be applicable to suggest that most automation research will fit within the design science research paradigm for the research who choose to execute their research in such a manner.

5. Evaluation of FMA

Van Belle (2004) presents a populated framework of model analysis based on the recommendations and propositions by more than ten researchers focusing specifically on the criteria that should be included in model evaluation, as summarised in Table 5-1 (as supported by the research of Fabbrini *et al.* (1998), Noël *et al.* (2022), Brazier and Wijngaards (1998), Weykamp *et al.* (2015) and Al-Khouri (2007)).

Category	**Syntactic**	**Semantic**	**Pragmatic**
Description	The syntactic elements of model analysis are concerned with the structure of the model	The semantic elements related to evaluating a model are concerned with the intrinsic meaning of the model	The pragmatic elements of model analysis are concerned mostly with the environment and the context of the model
Main Criteria	Size Correctness Modularity Complexity	Completeness Understandability Documentation	Validity Availability Support Purpose

Table 5-1: The Evaluation Criteria of a Model

Based on the criteria outlined in Table 5-1, with consideration of what the FMA model aims to achieve, an evaluation criteria checklist, as outlined in Table 5-2, can be used to evaluate the effective representation of a study using FMA.

Criteria	**Assessment**	**Explanation**
Does the FMA model accurately represent the syntactic elements of the study?	Yes	The framework of ideas details the primary and secondary framework of ideas that is largely focused on the scaling of the model from an approach and domain-specific environment into an environment that is considered more generalised. The inductive/deductive approach speaks to the correctness of the model while the domain-specific focus and area of interests speak to the modularity (as well as the complexity involved in the study). The methodology portion of the model also indicates the structure of the study with greater detail which speaks to the overall size of the study.
Does the FMA model accurately represent the semantic elements of the study?	Yes	The methodology portion of the FMA model covers the understandability of the study through the provision of the theoretical and practical aspects of the study which would, traditionally, be addressed through the research design and methodology. The methodology aspect of the model (broken into theory and practical) can be expanded to include and cover

		all aspects of the research design, lending itself to the completeness of the study. Where documentation is required (like in DSR implementations using TOGAF, for example), the area of interest as well as the methodology aspect of the FMA model will depict which documentation is required as part of this study. The ethical consideration could be included in this documentation.
Does the FMA model accurately represent the pragmatic elements of the study?	Yes	The pragmatic stance of the study would be addressed through each of the elements of the FMA model, namely: framework of ideas, methodology and areas of interest. Validity would be addressed as part of the theoretical aspects of the methodology while the purpose and availability would be covered through the elaboration on the area of interest. The support will be addressed through the framework of ideas as well as the primary and secondary areas of interest.

Table 5-2: The Evaluation of the Usage of the FMA Model

The semantic, syntactic and pragmatic evaluation of the model discussed in Table 5-2 is also subject to the contribution of the study defined through the use of the FMA model as each element of the model also specifies the categorical information that should be included in the model as amended from the initially proposed framework. The evaluation criteria, however lean it may seem, is actually quite packed with significance. The criteria could be further broken out with each element of syntactic, semantic and pragmatic approaches being evaluated individually. Based on the evaluation and explanations provided in Table 5-2, the FMA model may be adequately used to formulate a study while adhering to the most integral and core elements of a study.

6. Conclusion

FMA is a model that can be used to help researchers identify the context, or golden thread, that ties their study together. As demonstrated in this paper, FMA can be used to formulate the research methodology as it can encapsulate all information represented by the research onion and more. The FMA model can be expanded upon to include very specific information to the research being performed. Through the analysis of a research study that has already been executed, it can also be seen that the FMA model can be generalised enough to cater for any automation-orientated research, without being tied to a specific knowledge or industrial domain.

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