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CIRCULAR REASONING FOR THE EVOLUTION OF RESEARCH THROUGH A STRATEGIC CONSTRUCTION OF RESEARCH METHODOLOGIES

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ABSTRACT: *In a research process, the inductive and deductive reasoning approach has shortcomings in terms of validity and applicability, respectively. Also, the objective-oriented reasoning approach can output findings with some of the two limitations. That meaning, the reasoning approaches do have flaws as a means of methodically and reliably answering research questions. Hence, they are often coupled together and formed a strong basis for an expansion of knowledge. However, academic discourse on best practice in selecting multiple reasonings for a research project is limited. This paper highlights the concept of a circular reasoning process of which a reasoning approach is complemented with one another for robust research findings. Through a strategic sequence of research methodologies, the circular reasoning process enables the capitalisation of strengths and compensation of weaknesses of inductive, deductive, and objective-oriented reasoning. Notably, an extensive cycle of the circular reasoning process would provide a strong foundation for embarking into new research, as well as expanding current research.*

KEYWORDS: circular reasoning, inductive reasoning, deductive reasoning, objective-oriented reasoning

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INTRODUCTION

According to the Oxford dictionary (2020), research is defined as the search for knowledge, involving a systematic investigation of various aspects of the world focusing on the discovery, interpretation, correction, and reconfirmation of knowledge. Many professionals execute research in a quest for greater knowledge by understanding phenomena, building new methods and theories, and implementing new applications. Numerous studies are conducted in society, contributing to the establishment of newly asserted facts, reporting new knowledge, and reaching new conclusions.

According to Kuhn (1996), new knowledge seldom instantly emerges. It needs continuous development over an extended period to be realised. It also involves the accumulation of data and interconnection of information. Past and current studies work together in tandem, contributing to future studies, compensating for limitations, reinforcing advantages, and proposing directions for new research. Through such back and forth processes of reconstruction, refinement, and optimisation, the frontier of knowledge can be pushed outwards.

Experts, including Best (2011), Collins (2017), Creswell and Creswell (2017), Hutchinson and Barrett (2019), and Mejia-Perez (2020), have dedicated themselves to studying the nature and philosophy of research knowledge, such as the ontology, epistemology, and worldviews (e.g. positivism, constructivism, and pragmatism), research approaches (e.g. inductive/deductive, or exploratory/explanatory), and research methods (e.g. qualitative/quantitative, empirical/experimental, or mix methods). As part of efforts to facilitate the expansion of knowledge, many studies on building up effective research methodologies and their variety of processes and methods have been conducted (see Brown and Dueñas, 2020; Bryman, 2015; Dimitriou, 2019; Gray, 2013; Punch 2013; Vashishth and Chakraborty, 2019). Such studies shed light on the inevitable complexity of the research process, aiming to answer the targeted research question optimally.

Nevertheless, most of the research problems are intricate and often impossible to solve without fragmenting them into smaller sub-problems (Walliman and Walliman, 2011). A comprehensive research project, such as postgraduates' thesis commonly responds to multiple research questions. Once the research problems or questions are formulated, things started getting difficult for novice researchers. Often, novice researchers isolate the question and analyse it at the individual sub-unit level, but they struggle to get back to the big picture that they wanted to address (Baxter and Jack, 2008; Yin, 2003).

The various research questions require different approaches that are distinguished by their theoretical schema and methodologies (De-Xin, 2018; Walliman and Walliman, 2011). Notably, each strand of the research approaches and their methods has its strengths and weaknesses. Inductive reasoning, mainly involving qualitative research has limitations in the sense that the validity of the research is arguable. In contrast, deductive reasoning, primarily involving quantitative research, produces numerical evidence with a lack of applicability. Thus, a mix of reasoning approaches is often needed to enable exhaustive research, and it can be seen as a creative and versatile way to address myriad research problems (Giddings and Grants, 2006).

This paper enlightens the reciprocal relationship of the inductive and deductive approaches through a concept called the circular reasoning process. Agouridas et al. (2008), Dooley (2002), and Lynham (2002) have suggested a similar concept of circular reasoning for building research methodologies. However, such studies have limitations in that the studies end up proposing the basic concept without details of the concept application. How circular reasoning benefits different research worldviews, approaches, and methods remain unknown. Also, there is a lack of clarity regarding the relationship between the nature and philosophy of research. Such knowledge is essential as commonly novice researchers are uncertain in selecting an appropriate combination of research methodologies, worldviews and approaches, especially when they intend to build theories or models.

Therefore, this study highlights the concept of the circular reasoning process as a guide for novice and seasoned researchers alike. The concept addresses the relationship between research worldviews, approaches, and methods. The primary purpose of circular reasoning is to facilitate the setting of proper research direction in building theories or models through a complementary set of inductive and deductive reasoning. The idea is to capitalise the strengths and compensate for the weaknesses of each approach. Also, this study addresses an application of the circular reasoning process to a linkage between objective-oriented reasoning and inductive or deductive reasoning.

The remainder of this paper is organised as follows. First, Section 2 presents an overview of research worldviews, approaches and methods, framed as the components of the circular reasoning. Section 3 addresses the development of circular reasoning for the evolution of research, through the construction of research methodologies and reflection of their relationships. The section also unfolds case studies in which the circular reasoning process has been applied. In addition, the section explains how to avoid falling into logical fallacy when using circular reasoning. The final section envisages the contributions and summarises the circular reasoning concept.

AN OVERVIEW OF RESEARCH WORLDVIEWS, APPROACHES AND METHODS, AND THEIR INTERCONNECTION

According to Best (2011), Creswell and Creswell (2017), and Punch (2013), designing research methodologies involves an in-depth understanding of 'research worldviews', also known as 'research paradigms' and 'research philosophies' (e.g. positivism, constructivism, and pragmatism), 'research approaches' (e.g. deductive/inductive or explanatory/exploratory) and 'research methods (e.g. quantitative/qualitative, experimental/empirical, or mix methods). Depending on the research direction, different worldviews can be employed. Research worldviews are philosophical classification of different ways of thinking. It explains how humans rationally and logically approach and solve problems and in turn contribute to or create new knowledge: Guba (1990) defined the research worldview as "A basic set of belief[s] that guide[s] action". Importantly, research worldview plays a critical role in determining appropriate research approach and method. The interconnectedness of the corresponding worldview, approach and method is crucial in research (Best, 2011; Creswell and Creswell, 2017; Gray, 2013). A study that does not consider this interconnection may have flaws in that its premise could be conflicting to one of the underlying worldviews; between developing a descriptive and prescriptive model or theory, or between generating or

validating new model or theory. Such an imprecise approach could lead to failure in addressing the central research problem of a particular study and achieving its research objectives.

Research Worldviews

Many experts, including Bryman (2015), Collins (2017), and Creswell (2013), have classified research worldviews into several categories. The categories are 'positivism', 'constructivism', 'pragmatism', and 'transformative'. The latter is often substituted with 'realism' or 'criticism', depending upon the degree of significance that the researcher sets in their research direction. The three former categories are commonly regarded as representative worldviews when building theories or models (Best, 2011; Niglas, 2001; Saunders, 2011) and thus are discussed in this paper. The three worldviews can be approached from the viewpoint of 'ontology'; how a matter and its reality exist, and 'epistemology'; how a matter and its reality are perceived (Collins, 2017; Creswell and Creswell, 2017; Mertens, 2014).

Positivism

Positivists consider that a mater and reality are perceived objectively as an independent domain, which indicates that said matter has objective meaning and exists in and of itself (Best, 2015; Creswell and Creswell, 2017; Niglas, 2001; Saunders, 2011). Positivism is a grounded worldview and primarily used to generalise theories or models as a sort of 'law', through some means of verification, usually experimentation. However, this is not to say that this worldview is unsuitable for generating new theories or models. Rather than generating new theories or models, the worldview is more suitable to verifying hypothetical theories or models that already exist or are newly discovered. The verified theories of models will then emerge as a piece of new knowledge.

Constructivism/Interpretivism

The perspective of the constructivists which includes interpretivists (Stake, 1995) is that a matter and its reality are constructed differently by different interpretations of individuals in different contexts (Best, 2015; Creswell and Creswell, 2017; Niglas, 2001; Saunders, 2011). This way of thinking allows the perceived matter to be reconstructed, hence creating new realities. Constructivism is thus a research philosophy that enables the creation of new theories or models and concretes them through contextual interpretations. However, this does not imply that this worldview is not appropriate for validating new theories of models. Under this worldview, whether a generalised theory or model is applicable to subspecialised domains and how they can be concreted in each domain can be validated. Therefore, constructivism is more suitable for building new theories or models and making them concrete but can also be used to validate generalised theories or models for a specific application.

Pragmatism

Pragmatists tend to focus on devising practical research methods than ideal (actions and practices) to solve given problems and achieve targeted objectives (Best, 2015; Creswell and Creswell, 2017; Niglas, 2001; Saunders, 2011). Pragmatism is a problem-based, objective-oriented and practice-centred worldview. In the process of finding workable solutions, concepts from positivism and constructivism are sometimes coupled together,

hence creating contentious dualistic philosophies. However, pragmatism approach may also defy these two worldviews entirely. Often, researchers adopt approaches that they deem sensible and rational to accomplish research objectives.

Strengths and Shortcomings of the Research Worldviews

The worldviews above have advantages and disadvantages. Researchers commonly validate them using a set of logical basis, considering whether the research is to solve problems, contribute to existing theories or models, or create new ones. Also, researchers who embrace a particular worldview tend to criticise the negative implications of other worldviews. For example, positivists may argue whether a theory or model built under constructivism can be accepted as universal knowledge furthermore if the model and theory are too specific to be generalised. Conversely, if a particular theory or model has limits on its applicability in different contexts, constructivists raise objections over whether such a theory or model can indeed be said to be universal knowledge. Meanwhile, pragmatists argue that the most rational way of thinking is to first fundamentally perceive what the problem to be tackled is and then to concentrate on finding a solution. They deem that such a mental model is the most suitable way of producing an optimal theory or model. In a counter-argument, positivists and constructivists believe that the pragmatists' approaches may be prone to logical error, mainly if the chosen method relies heavily on individual judgement. The result is a set of mutually exclusive theorems that undermine each other, and the 'logical' conclusion would then be that none of these is correct.

Therefore, much research proposes that the adoption of appropriate worldviews is subject to the output of research. In research seeking to build a more concrete theory or model based on contextual interpretations with subjective perceptions of certain phenomena, constructivism is nevertheless regarded as an appropriate research worldview. In research aiming to generate a more generalised theory or model based on asserted factual results with objective perceptions, positivism is considered the most relevant. In research intending to find a new theory or model as the most rational method or solution to a research problem, pragmatism may be the most suitable research worldview.

Research Approach

This section outlines research approaches for different research worldviews.

Deductive Reasoning (mainly involving quantitative research)

Deductive reasoning is typically suitable for research under positivism (Creswell, 2013; Johnson and Onwuegbuzie, 2004; Mackenzie and Knipe, 2006; Mertens, 2014; Niglas, 2001; Saunders, 2011). Research using deductive reasoning would generally have the following characteristics:

1) Based on existing knowledge (e.g. from the literature review), a hypothetical theory or model is built, which is then related to research directions
2) The hypothetical theory or model is verified iteratively, with many, quantifiable data points
3) If the outcomes of the validation are satisfactory, the theory of model can be considered as law-like. In contrast, if the outcomes of the validation are not

satisfactory, the overall research can be deemed as new knowledge that can be used as a reference for further research.

The generation of particular theories and models through validation with large quantities of numerical data aligns with the underlying belief of positivism. That meaning, a matter and reality are recognised objectively by which they can be proven with sufficient numerical data (e.g. statistical data). Therefore, in general, deductive reasoning primarily involves a large quantity of measurable information. Further, the numerical interpretation of that information is made objectively, followed by the process of validation and generalisation. Thus, deductive reasoning is commonly used in explanatory research.

Undeniably, quantitative data is precise and objective, and thus is appropriate for testing and demonstrating a theory or model. Despite its robustness, quantitative data can sometimes be too superficial, lack of detailed narratives and insights. The overly narrow results of quantitative data are not appropriate to answer the 'why' and 'how' of research questions.

Inductive Reasoning (mainly involving qualitative research)

Inductive reasoning is relatively more appropriate for studies employing constructivism (Creswell, 2013; Johnson and Onwuegbuzie, 2004; Mackenzie and Knipe, 2006; Mertens, 2014; Niglas, 2001; Saunders, 2011). Research using inductive reasoning would commonly have the following characteristics:

1) Obtaining knowledge (e.g. from the literature review) related to research directions
2) Understanding phenomena by carrying out qualitative data collection and analysis considering the research as well as the attained knowledge
3) Developing a new theory or model as new knowledge, based on the new understanding

The inductive reasoning fits the grounded thoughts of constructivism of which a matter and reality are reconstructed and concreted through contextual interpretations, consequently creating a new reality. It is well known that inductive reasoning generally involves mainly qualitative information. Examples of qualitative data are written text and verbal responses. Such data will be analysed using hermeneutics approach of which the data is interpreted rationally to enable the development of a new theory. Thus, inductive reasoning is generally used in exploratory research.

Qualitative data can be useful to describe complex phenomena which occur in specific contexts, e.g. by conducting cross-case comparisons and interpretations. However, data obtained can be easily influenced by researchers' bias and limitation, such as the mastery of language and tacit knowledge. Such factors may output a comparatively lower validity of research and, may lead to imprecision in verifying theories or models and in generalising them.

Objective-oriented Reasoning (mainly involving mixed methods)

In objective-oriented approach, both quantitative and qualitative data are involved, either in different phases of studies or intertwined together, depending upon the significance of the two data types and what those types intend to solve research

problems or achieve research objectives (Creswell, 2013; Johnson and Onwuegbuzie, 2004; Mackenzie and Knipe, 2006; Mertens, 2014; Niglas, 2001; Saunders, 2011). The mixed-methods approach is generally used when the research directions to understand multiple types of phenomena simultaneously, something which requires both quantification and contextual interpretation. The approach aims for an optimal outcome by drawing on the strengths of each data type and attempts to counterbalance their weaknesses. Therefore, the mixed-methods approach encapsulates the philosophy of pragmatism that mainly focuses on devising effective research methods to solve given problems or achieve established objectives.

A Summary of the Research Approaches

Qualitative research using inductive reasoning under constructivism is more suitable to be conducted when building theories or models. Conceptually, the approach is executed by reconstructing phenomena to obtain a fresh value and an explicit understanding of the phenomena. In contrast, quantitative research using deductive reasoning under positivism is more relevant to validate theories and models and generalise them. The approach is executed by observing the numerical values of phenomena. Meanwhile, when the research direction requires both objective cognition and contextual interpretations of phenomena, mixed-methods research using objective-oriented reasoning under pragmatism is more appropriate to be employed.

Research Methods

Research methods are classified depending on the research paradigm and the relevant approach (Best, 2011; Bryman, 2015; Punch, 2013; Creswell and Creswell, 2017). As illustrated in **Figure 1**, many experts, including Niglas (2001) and Saunders (2011), have devoted studies to this area. The classification considers which research worldview and approach is more appropriate to both the nature and characteristics of each research method. Broadly speaking, experiment-based methods mainly involving quantitative data are more suited for positivism, while empirical-based methods primarily involving qualitative data are more appropriate for constructivism.

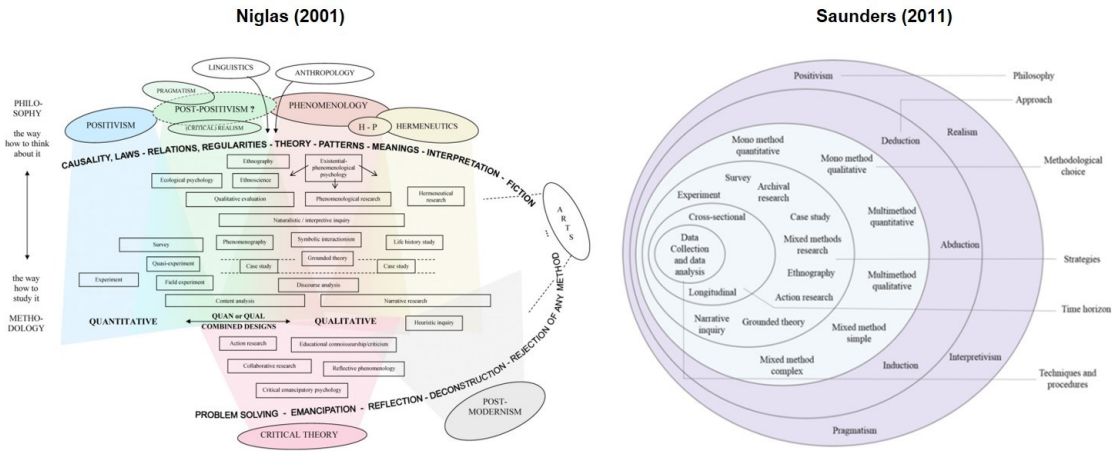

Figure 1. Classification of research methods based on research paradigms and approach [adopted from studies by Niglas (2001) and Saunders (2011)]

However, not all methods can be categorised under the generic standard. For instance, although a questionnaire survey is not an experiment-based method, the method aligns well with deductive reasoning under positivism. The gist of the method is to understand the general status of a particular matter or phenomena through quantitative data and to generalise that understanding into a theory or model. generalise that understanding into a theory or model.

It is also noteworthy to highlight that even within the same research method, worldviews can differ depending on the direction of the study at hand. Hence the methods of data collection and analysis can differ accordingly (Baxter and Jack, 2008; Yazan, 2015). For example, in the case where an interview was conducted as one of the case study approaches, a study by Yin (2013) adopts positivism, whereas Boblin et al. (2013) and Stake (2013) embrace constructivism. There are also studies which adopt research worldview that falls in between the two but slightly inclined towards positivism, e.g. Eisenhardt (1989), Eisenhardt and Garebner (2007) and Steenhuis and De Bruijn (2007).

For example, the followings are brief descriptions of classifications of the interview analysis methods and their corresponding research worldviews.

1) *Ground Theory and Thematic Analysis*
   Eisenhardt's method (1989) in which 'Ground Theory', consisting of three coding steps, 'Open Coding', 'Axial Coding', and 'Selective Coding' (Glaser, 1999; Strauss and Corbin, 1990) is commonly used under positivism. Also, Yin's method (2003; 2011; 2013) in which 'Thematic Analysis (Braun and Clarke, 2006; Judger, 2016; Vaismoradi et al., 2013) provides a methodical set of seven steps is generally used under positivism. Eisenhardt's and Yin's methods aim to discover common patterns which accord with a predefined coding scheme and then converting these common patterns into the form of a theory or model. They are beneficial for developing conceptual theories or models based on patterns identically revealed in interview scripts.
2) *Content Analysis*
   'Content Analysis' (Graneheim and Lundman, 2004; Hsieh and Shannon, 2005; Vaismoradi et al., 2013) is also utilised under positivism. The content analysis method, which takes notice of the number of content repeats, is widely used with qualitative information. Thus, this method is more suitable for understanding which kinds of phenomena occur how often. Therefore, finding quantifiable factors is to see particular patterns and the frequencies of the repeated contents in interview scripts to make generic conclusions by putting everything together in more acceptable for developing conceptual theories and models.
3) *Conversation Analysis and Discourse Analysis*
   The grounded thought underlying the following two methods, 'Conversation Analysis' (Hutchby and Wooffitt, 1998; Ten Have, 2007) and 'Discourse Analysis' (Burman and Parker, 2016; Willing, 2003), are aligned with that of Stake (1995), a representative constructivist (Braun and Clarke, 2006). These two methods are more appropriate for understanding complex information and reconstructing said understanding, by faithfully focusing on hermeneutical meanings. These methods result in building concreted theories or models rather than conceptual theories or models. 'Conversation Analysis' is generally more appropriate for extracting

connoted meanings form conversations (as its name would imply), with considerations of the contextual relationship the interviewer and interviewee(s). 'Discourse Analysis' is more suited for analyses of the same script can be interpreted differently depending on the historical, socio-culture, environmental, and political backdrop.

4) *Phenomenological Analysis*
The way of thinking that is elemental to 'Phenomenological Analysis' (Giorgi, 2009; Giorgi and Giorgi, 2008; King and Horrocks, 2010) is aligned with that of the constructivists, e.g. Stake (1995; 2010; 2013). Phenomenological Analysis' consists of a four-phased analysis process. The process focuses on hermeneutical meanings and is undertaken phrase by phrase, and clause by clause. This method is essential to understand complex information and to reconstruct said understanding. The systematic concretisation of such information leads to the emergence of concreted theories or models. In the case of 'Interpretive Phenomenological Analysis' (King and Horrocks, 2010) which has a similar name, its grounded thought is aligned with that of the positivists in that its analysis mechanism is similar to 'Thematic Analysis'.

As indicated, the selection of research methods has to be based on the relationship between the research directions, the nature and characteristics of methods, and the grounded thought underlying worldviews. The incongruity between the methods and the worldviews may sway the overall research process hence diverge from the initial research direction.

Figure 2 shows the relationship between research worldviews, approaches, and methods (notably, the interview method). The first loop depicts that if the research direction is to develop a concrete and specific theory or model by understanding and reconstructing certain phenomena, it is more appropriate to employ the constructivists' method using inductive reasoning. For the second loop, the methods of positivists will be more relevant than those of constructivists if the research direction is to develop a generic conceptual theory or model. The third loop indicates that if the research is multi-dimensional in nature, a mixed-methods under pragmatism would be the most suitable approach to be employed. Besides, methods under the constructivist and positivist paradigm can be adopted as part of pragmatism.

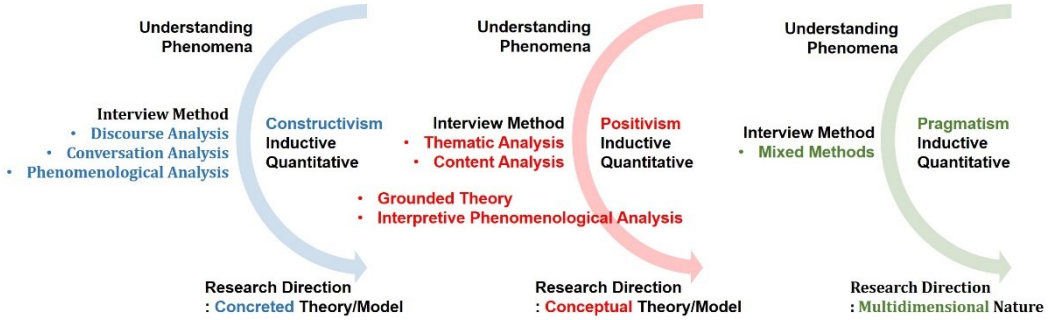

Figure 2. An example of the relationship between research directions, worldviews, approaches, and methods

Therefore, we need to carefully consider the reciprocal linkage between the research directions, research worldviews, approaches and methods. A common misconception is

that the execution of more research methods in research would increase the validity of the research. Some scholars undiscerned the use of multiple research methods, e.g. case study methods, including interviews, questionnaires, observations, focus group and the Delphi method, used in conjunction (Dooley, 2002; Lynham, 2002). Undoubtedly, random use of research methods without the consideration of their interconnections may lead the research going off-track, losing focus, and consequently fail to meet its objectives. It is noteworthy to highlight that many methods are imprudently adopted in the name of pragmatism. Pragmatism does not grant the idea of merely using multiple diverse methods, but instead, those employing pragmatism should practically seek appropriate methods to matching with the research directions.

A CIRCULAR REASONING PROCESS FOR RESEARCH EVOLUTION

We propose the concept of circular reasoning process to evolve research through a continuous and relevant series of research methods. In a nutshell, the concept sheds light on the circular relationship of research worldviews, approaches and methods. Predominantly, it enables the researcher to reflect on the back and forth interaction between the inductive and deductive reasoning, as well as the objective-oriented reasoning.

Figures 3 to 8 depicts the cycle of the circular reasoning process. In the figures, each reasoning archetype, which makes up half of the loop, has been positioned with the consideration of the interconnection between the corresponding research directions, research worldviews, approaches and methods. The following sub-sections detail the operational mechanism for the three types of circular reasoning and present empirical case studies that have adopted the circular reasoning process.

The First Circular Relationship between Inductive and Deductive Reasoning

Figure 3 (Steps ❶ to ❻) shows the progression of research from inductive to deductive reasoning. Within these steps, a concrete new theory or model is developed first, through contextual interpretations and reconstructions of qualitative data, using inductive reasoning under the constructivism paradigm. Subsequently, deductive reasoning approach under positivism is conducted by which the concrete theory or model (which can be regarded as a hypothetical theory or model) is verified using quantitative data analysis. Once verified, the theory or model is ready to be conceptualised or generalised (closer to be generalised), producing a conceptual theory or model (Steps ❹ to ❻).

Thus, in the first loop, the comparatively low validity of the theory or model developed using qualitative data analysis with inductive reasoning under constructivism (Steps ❶ to ❸) [even if a data triangulation is done at this stage to strengthen internal validity (Yazan, 2015)], is further reinforced with the following deductive reasoning approach under positivism (Steps ❹ to ❻).

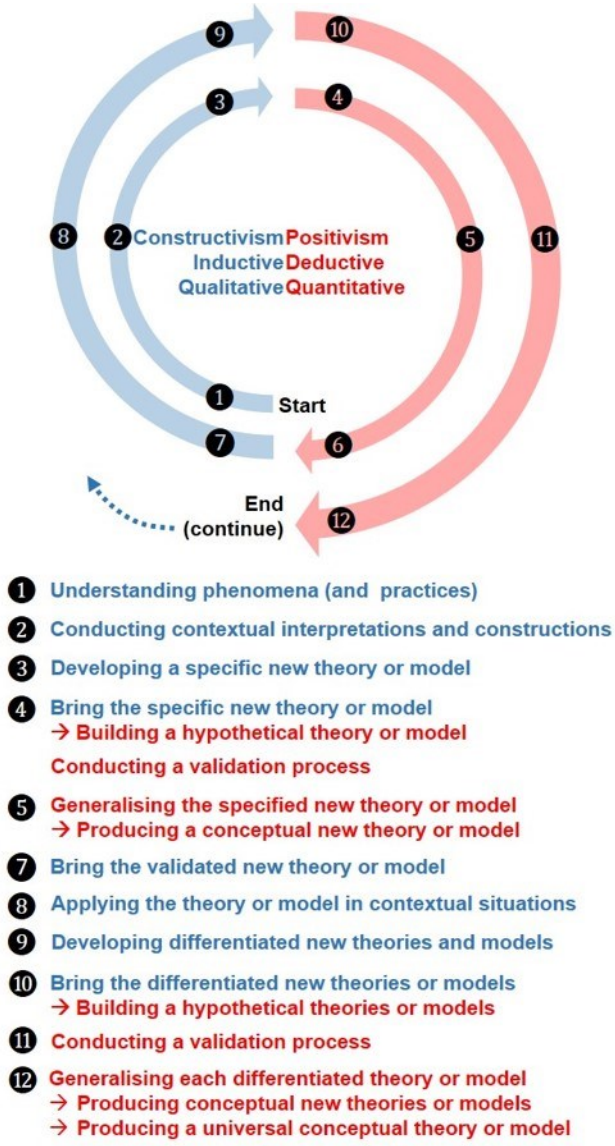

Figure 3. The first circulatory relationship between inductive and deductive reasoning

In the subsequent research flow from inductive back to deductive reasoning (Steps ❼ to ⓬), the validated theory or model in the previous deductive reasoning approach under positivism is differentiated (specialised) into subdivided theories or models. The specialisation is done by reconstructing the data for different contextual situations, through qualitative data analysis, using inductive reasoning under constructivism (Steps ❼ to ❾). Further, the research process is continued using the following deductive reasoning approach under positivism by which each differentiated theory or model is validated using quantitative data analysis. These steps aim to either produce an individual conceptual model or theory or to identify a more advance single and universal conceptual theory or model (Steps ❿ to ⓬).

As previously discussed, the basis of the circular reasoning process is the interplay between inductive and deductive reasoning. The process taps on and counterbalances the strengths and weaknesses of each reasoning, respectively. Thus, steps ❼ to ❾

(inductive) of the loop addresses the shortcomings of steps ❹ to ❻ (deductive). Afterwards, the deficiencies concerning lower validity caused by steps ❼ to ❾ (inductive) are improved by a validation process in steps ❿ to ⓬ (deductive).

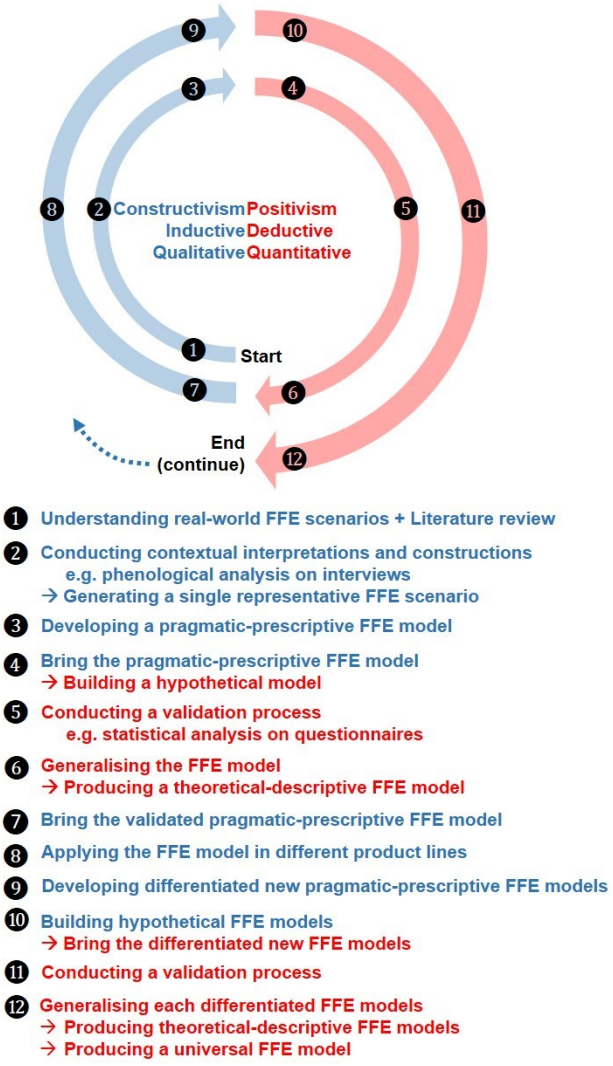

Figure 4. Research activities throughout the cycles of the first circular relationship between inductive and deductive reasoning

Figure 4 shows the research activities that are carried out following the cycles of the first circular reasoning process. The application of these cycles can be found in a study by Park (2018). In the study, on specification is a challenge in new product development (NPD) as information may not be known with certainty at the outset of design and this period is sometimes referred to as the fuzzy front end (FFE). As indicated in Figure 4, in the initial loop from inductive to deductive reasoning (Steps ❶ to ❻), a concrete FFE model that is applicable to NPD, is first developed with inductive reasoning (Steps ❶ to ❸), using the constructivists' method (phenomenological analysis of interviews) by which the understanding of the real-world FFE scenarios is contextually deconstructed. In the subsequent deductive reasoning approach (Steps ❹ to ❻), the FFE model (which can be considered to be a hypothetical model) was validated by

applying it to actual NPD programmes using positivists' method (statistical analysis of questionnaire data). Based on the validation results, the FFE model developed was closer to be generalised under positivism, producing a conceptual theory, putting the mathematical reasoning behind the performance structure of the model.

In the study, the continuity of the loop from inductive back to deductive reasoning (Steps ❼ to ⓬) was suggested as the future research direction. In the inductive reasoning phase, the concreted FFE model validated in the previous deductive reasoning approach will be applied differently to various types of products (Steps ❼ to ❾). The application is executed using the constructivists' methods to see how the FFE model can be fine-tuned to such variations. Within the following deductive approach (❿ to ⓬), the subdivided FFE models will be validated using the positivists' methods. Also, possibly, the subdivided models will be improved into a single universal model that is better than the current one.

The Second Circular Relationship between Deductive and Inductive Reasoning

Figure 5 (Steps ❶ to ❻) shows the progression of research from deductive to inductive reasoning. In the first cycle (Steps ❶ to ❻), a hypothetical theory or model is generalised (or closer to be generalised). The process is done through a robust verification process by means of quantifiable data analysis using deductive reasoning under positivism (Steps ❶ to ❸). Then, the conceptual theory or model which has been generalised (or closer to be generalised) is differentiated (specialised) by applying it to different contextual situations. The process is executed by using qualitative data analysis of the inductive reasoning approach under constructivism (Steps ❹ to ❻).

Within the cycle, the limitations in the theory or model, which is generalised (or closer to be generalised) using quantitative data analysis of the deductive reasoning approach under positivism (Steps ❶ to ❸), reduces the study's applicability to contextual situations. These limitations can be mitigated using qualitative data analysis in the subsequent inductive reasoning approach under constructivism (Steps ❹ to ❻).

Within the loop where the research moves from deductive back to inductive reasoning (Steps ❼ to ⓬), each differentiated theory or model is initially verified using quantitative data analysis. This process either produces each generalised theory or model or confirms a more improved universal conceptual theory or model (Steps ❼ to ❾). Afterwards, in inductive reasoning under constructivism, each generalised theory or model (or one universal theory or model) is materialised by applying it to other contextual situations using qualitative data analysis (Steps ❿ to ⓬).

In the latter cycle, the relatively low validity of the concreted theory or model derived from the qualitative data analysis of the inductive reasoning approach in Steps ❹ to ❻ is reinforced by the subsequent deductive approach in Steps ❼ to ❾. Again, the deficiencies of the theory or model stemming from numerical data analysis in deductive reasoning under positivism (Steps ❼ to ❾) give the study relatively lower applicability. Hence, the applicability of the research is strengthened by qualitative data analysis of the subsequent inductive reasoning approach under constructivism (Steps ❿ to ⓬).

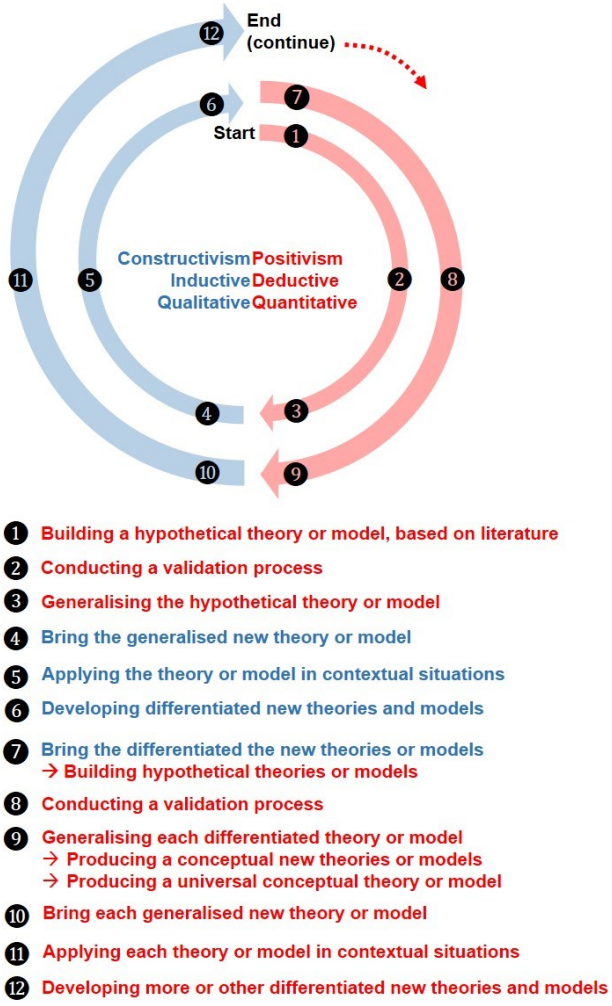

Figure 5. The second circular relationship between deductive and inductive reasoning

Figure 6 shows the research activities that are carried out following the cycles of the second circular reasoning process. The application of these cycles can be found in a study by Han (2018). Started with deductive reasoning under positivism (Figure 6), the research developed two creative ideation tools to support designers in creative concept generation. The tools were derived from a theoretical background search (Step ❶). The research then validated those tools using the positivists' methods (statistical analysis of questionnaires) (Steps ❷ to ❸). Since the tools are meant for general use, we cannot confirm whether they can be used effectively in different contexts, e.g. different types of NPDs. Therefore, further application of the proposed tools can be verified through subsequent qualitative data analysis of the inductive reasoning approach under constructivism (Steps ❹ to ❻). In the following progression of the research cycle, that is from deductive back to inductive reasoning (Steps ❼ to ⓬), each specialised tool can be validated and brought closer to be generalised again. The process is done through quantifiable research methods, seizing an opportunity to integrate them into a single advanced tool (Steps ❼ to ❾). Finally, each validated tool (or a single advanced tool) can be applied to different contextual situations and further concreted again (Steps ❿ to ⓬).

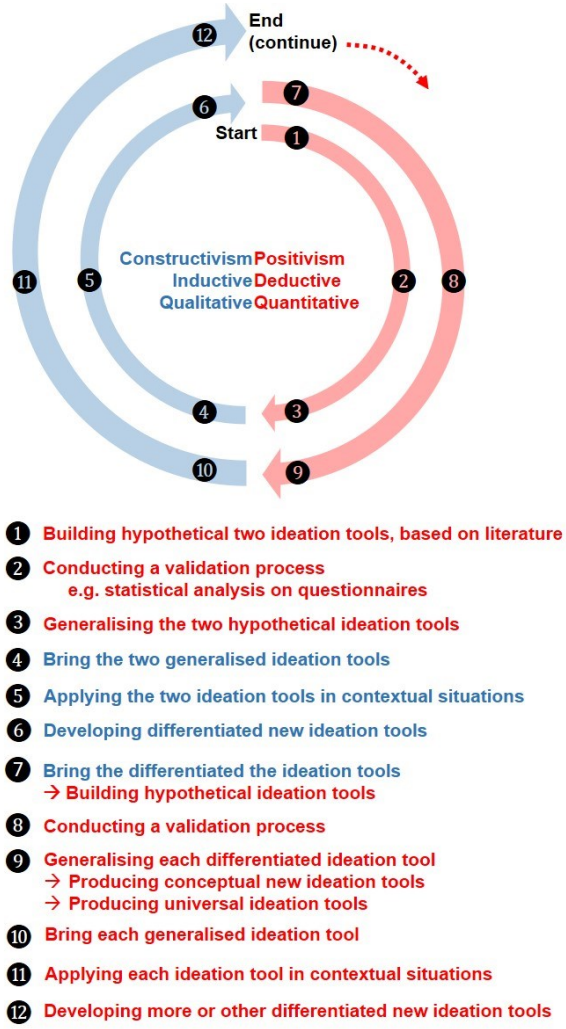

Figure 6. Research activities throughout the cycles of the second circular relationship between deductive and inductive reasoning

The Third Circular Relationship between Objective-oriented and Inductive or Deductive Reasoning

Figure 7 shows the cycles of the third circular relationship between objective-oriented and inductive or deductive reasoning. A research project that starts with objective-oriented reasoning can be mobilised through two routes (steps ❶ to ❾). A concreted (or conceptual) new theory or model is developed using objective-oriented reasoning under pragmatism, through a mixed analysis on the frequency of the phenomena (quantitative data analysis) and the hermeneutic understanding of the phenomena (qualitative data analysis) (Steps ❶ to ❸). Then, in the first route that connects to inductive reasoning under constructivism, the theory or model is applied to different contextual situations to examine their applicability and thus further concreted (Steps ❹ to ❻). Further, the theory or model is validated using quantitative data analysis in the second route that links to deductive reasoning under positivism. Based on the validation results, a concreted (or conceptual) theory or model can be close to being generalised (further generalised and thus relatively has robust validity) (Steps ❼ to ❾).

Briefly, in the aforementioned cycle, the relatively low applicability of the initial theory or model developed using the mixed-methods (quantitative and qualitative) with objective-oriented reasoning under pragmatism (Steps ❶ to ❸) is counterbalanced by the subsequent inductive reasoning approach under constructivism (Steps ❹ to ❻). Also, the comparatively low validity of the new theory or model developed (Steps ❶ to ❸) is compensated through the validation process in the following deductive reasoning approach under positivism (Steps ❼ to ❾).

Figure 7. The third circular relationship between objective-oriented reasoning and inductive or deductive Reasoning

In the next cycle, the applicability of the model and theory (Steps ❹ to ❻) can be validated by quantifying data, using deductive reasoning under positivism (Steps ❿ to ⓬). On the other hand, the validated model and theory (Steps ❼ to ❾) is applied to different contextual situations to identify its concreteness. The process is done by interpreting the qualitative data of the phenomena, using inductive reasoning under constructivism ⓭to ⓯). Furthermore, depending on the newly established research trajectory, once again the model or theory [(Steps ❹ to ❻) or (Steps ❼ to ❾)] can

be further improved by using the mixed-methods of objective-oriented reasoning under pragmatism (Steps ⓰ to ⓲).

In the aforementioned cycle, the weaknesses of each study which come from the corresponding reasoning approach previously conducted can capitalise on the strengths and compensate for the weaknesses of each reasoning approach, through conducting the subsequent different reasoning approach.

In the same context, a study initiated by inductive or deductive reasoning can also be followed by a study conducted through the mixed-methods using objective-oriented reasoning under pragmatism. Nevertheless, this process must be done by considering the research directions. The progression of research of this cycle is similar to the operation from [Steps ❹ to ❻ (or Steps ❼ to ❾)] to [Steps ⓰ to ⓲].

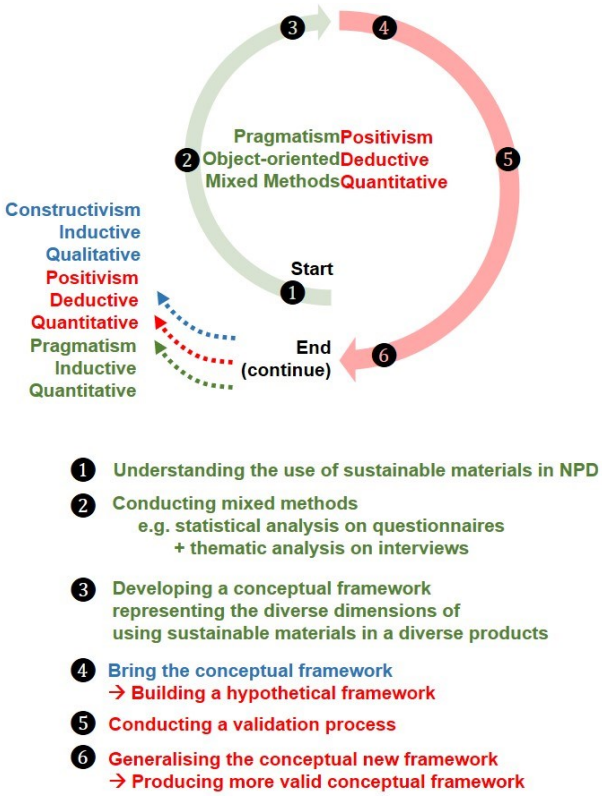

Figure 8. Research activities throughout the cycles of the third circular relationship between objective-oriented reasoning and inductive or deductive Reasoning

The application of the third circular reasoning can be found in a study by Bahrudin (2019). The research explored the experimental dimensions of sustainable materials of which a list of biographical information of material is identified as the intangible aspects that would alter user perception towards sustainable materials. As indicated in **Figure 8**, the research started with objective-oriented reasoning under pragmatism (Steps ❶ to ❸). That meaning, initially, the research quantified the application of sustainable materials in design projects as well qualitatively investigated the breadth development of the materials. This process is followed by a couple more qualitative studies that further investigated the intangible elements of sustainable materials and users' responses

towards them. Subsequently, a deductive reasoning approach under positivism is carried out (Steps ❹ to ❻). In such steps, the conceptual framework of user-sustainable material interaction was validated through quantifiable data analysis (statistical analysis of questionnaires), to examine the effect of the intangible elements of sustainable materials. The findings solidify the elements in the framework. Such steps of deductive reasoning under positivism has increased the validity of the conceptual framework that is initially developed by using objective-oriented reasoning under pragmatism.

Flexible Use of the Circular Reasoning

The three modes of circular reasoning process have shown that the inductive, deductive and objective-oriented reasoning process, research worldviews and associated research methods do not necessarily have to follow the general rational relationship. While the basic frame of circular reasoning should be maintained, the research worldview and associated methods can be used differently in each reasoning process, depending on the research directions.

For instance, a study by Han (2014) aimed to develop a conceptual theory about the characteristics of design leaders during the FFE. The research problem was initially approached using inductive reasoning (which is usually used under constructivism). Nevertheless, a thematic analysis (which is closer to positivist' method) was used to see the common patterns on how design leaders communicate a design to non-designers during the FFE phase. Through the method, 617 initial codes that were identified in the first step were reduced to 7 principal codes (which matches with the predefined codes) in the final step. Further, the 7 codes were used to build up the conceptual framework. Although the framework was close to a generalised theory due to the nature of the thematic analysis used, it has relatively lower validity. The limitation can be attributed to the intrinsic bias of language-based qualitative data analysis. Therefore, the research can be expanded in the future with the subsequent deductive reasoning approach by which the conceptual framework can be validated using a quantitative method (e.g. statistical analysis of questionnaires) under positivism. The aim is to investigate how those 7 components of the framework affect each other. This validation step can potentially increase the generalisation of the framework, producing a more refined conceptual framework.

The Logical Fallacy of the Circular Reasoning Process

In using the proposed circular reasoning process, researchers should be aware of the potential of a logical fallacy in which an argument starts with what it is trying to end with (Dowden, 2003; Nolt et al., 1998; Walton, 2008). For instance, in determining the location of James's house, an argument is that his house is to the right of Tom's. If this is so, in reasoning the location of Tom's house, what if there is another argument that Tom's house is to the left of James's? This is an example of the logical fallacy of circular reasoning. Sticking with the house analogy, one method to overcome this logical error is with the following steps: 1) Identify the location of James's house objectively using deductive reasoning, e.g. 123 Main Street; and then 2) Determine the contextual relationship between the location of Tom's and James's houses using inductive reasoning, e.g. Tom's house is to the left of James's and finally; 3) Infer the specific location of Tom's house, e.g. 125 Main Street. In this way, any possible logical fallacy

can be reduced. Also, different research types, methods and resources can be adopted between each reasoning. For instance, empirical-based research methods can be executed in the initial cycle of inductive reasoning under constructivism. This is followed by deductive reasoning under positivism that consists of experiment-based research methods. Conversely, experiment-based methods can be implemented in the initial deductive reasoning approach under positivism, and empirical-based methods can be conducted in the following inductive reasoning under constructivism.

Cycle of the Circular Reasoning Process

The proposed circular reasoning process which considers the general rational relationship between research directions and associated research worldviews, approaches and methods can be used to evolve modern research continually. Within the three modes of the circular reasoning process, each cycle of research progression within them is represented by one of the following:

1) [Inductive reasoning under constructivism] to [Deductive reasoning under positivism]
2) [Deductive reasoning under positivism] to [Inductive reasoning under constructivism]
3) [Objective-oriented reasoning under pragmatism] to [Inductive reasoning under constructivism (or Deductive reasoning under positivism)]
4) [Inductive reasoning under constructivism (or Deductive reasoning under positivism)] to [Objective-oriented reasoning under pragmatism]

Depending on the research directions, the four cycles of circular reasoning provides a basic structure, but the research worldviews and related research methods can be flexibly involved. Thus, when utilising the circular reasoning process, the focus should be given to the interconnection between the research worldviews, approaches, and methods, but researchers should not overlook what the research ultimately want to pursue (referred to as research directions).

DISCUSSION AND CONCLUSION

This paper elucidates the issue of adopting multiple reasoning approaches to address a research problem. The circular reasoning process has been proposed for the continuous evolution of research with a focus on building theories or models. The circular reasoning is grounded on the need to not only augment the strengths but also to address the weaknesses of each research approach:

1) Inductive reasoning which generally involves qualitative data under constructivism has limitations in that it gives research relatively lower validity
2) Deductive reasoning which commonly involves quantitative data under positivism has shortcomings in that it gives research comparatively lower applicability in different contextual situations
3) Objective-oriented reasoning which typically involves mixed methods under pragmatism tends to have partial deficiencies which the two reasoning approaches above have. Also, research methods with objective-oriented reasoning may prone to a logical error in that the methods rely heavily on individual judgement.

With circular reasoning, research can be refined and advanced by continuous processes of reconstruction, differentiation, integration, application, optimisation, and generalisation. One cycle of circular reasoning can lead to the generation of all four types of typical academic research outcomes: 1) understanding phenomena, 2) theory or model development, 3) theory or model application, and 4) theory or model generalisation. Furthermore, the iterative cycles of circular reasoning enable 1) phenomena reconfirmation/disconfirmation (reconstruction/deconstruction), 2) theory or model advancement, 3) theory or model operationalisation, and 4) establishment of law.

Three modes of the circular reasoning process that address different research problems and their corresponding research worldviews, approaches and methods have been identified. Simply put, the three modes demonstrate the breadth of research problems that require different cycles of steps to address the sub-problems. Essentially, this novel finding enriches the existing literature on individual and multiple reasoning approaches as well as their relationship. The circular reasoning process can serve as a quick reference for novice researchers and seasoned researchers alike in constructing research methodologies for the continuous evolution of research with a focus on building theories or models. It is noteworthy to highlight that the application of the circular reasoning processes has been found prominently in design research, e.g. product design, design engineering. However, the circular reasoning process can be applied extensively in other disciplines such as social sciences, applied sciences and even natural sciences. The shared nature of such disciplines is to discover new knowledge by understanding phenomena, building new theories or methods, and implementing new applications.

To conclude, the circular reasoning that encompasses the relationship between research directions, and associated research worldviews, approaches and methods are not strict law that researchers must follow. Also, circular reasoning is not a perfect approach to all disciplines of research. Some studies may continuously evolve using the same reasoning approaches, in all cycles of the research. However, we deem that much research, particularly the design research, can evolve using the circular process. By and large, depending on how opportunities are seized as future research directions, the circular reasoning process enables a more robust basis for starting a research project and continuing current research.

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