





Constructing a Design Research Model—Exploration of Research Paradigms Based on Research Tree Diagram

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ABSTRACT

The research paradigm is the foundation for the construction of the design research model. This study starts from the research paradigm to construct a design research model: the Research Tree Diagram. The crown part of the model presents the different levels of design research from five aspects: ontology, epistemology, methodology, approaches to theory development, research strategies, and data sample ethics. The root of the model shows the influence sources of design studies as an interdisciplinary field. As an information visualization tool, the Research Tree Diagram graphically delineates the multifaceted nature of design research, enabling researchers to systematically comprehend its intrinsic logic and interconnections. For novice researchers, it serves as a pedagogical scaffold to rapidly grasp design research methodologies. The model's efficacy is validated through a case study that demonstrate its practical application in structuring and executing design research projects. This example illustrates how the diagram facilitates the alignment of theoretical frameworks with empirical practices, ensuring methodological coherence.

KEYWORDS

Paradigm; Research Paradigm; Research Model; Research Tree Diagram; Design Research

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1. Concept of Research Paradigms

Social science research relies on implicit presuppositions. These presuppositions encompass the fundamental value beliefs of social scientists and their latent intentions regarding research topics (Jiang Yimin 2011). The concept of 'paradigm' can describe these basic images and underlying knowledge assumptions. First, it is essential to clarify the basic concepts of "paradigm" and "research paradigm." What exactly is a paradigm? Thomas Kuhn (1922–1996) first introduced the concept of paradigm in his 1962 book *The Structure of Scientific Revolutions*. Kuhn did not provide a precise definition but argued that the history of science is a series of paradigm shifts. His notion of "paradigm" includes laws, theories, standards, and methods—a set of beliefs that constitute a scientific discipline's worldview and shape how scientists perceive the world. A paradigm serves as an interpretive framework and a set of guiding principles for researchers. Academic consensus on the concept remains elusive, and related definitions include the following (Figure 1):



Figure 1. Concept of a Paradigm

- LeCompte and Schensul (1999) define a paradigm as: A paradigm sets a method that allows us to explore the world, interpret what we observe, and determine which aspects are real, valid, and worthy of documentation.
- Debates on paradigms peaked in the 1980s. Egon G. Guba, a leading figure in paradigm discussions, posited that a paradigm is a structural network woven from a researcher's ontology, epistemology, methodology, axiology, and rhetoric (Guba, 1990).
- Luo Shengqiang et al. (2014) describe a paradigm as a specific mode of thinking—a field's common beliefs and practices at a given time. Examples include evolution as a fundamental paradigm in modern biology, relativity in cosmology, and postmodernism in contemporary philosophy.
- Paradigms are also termed "knowledge claims" (Creswell, 2011) or philosophical assumptions encompassing ontology, epistemology, axiology, and methodology. Philosophically, a paradigm addresses: *What is knowledge?* (ontology), *How do we know it?* (epistemology), *What is its value?* (axiology), *How do we articulate it?* (rhetoric), and *What procedural steps guide its study?* (methodology) (Creswell, 2021).
- (Morgan 2007) defines a paradigm as: A shared system of thought that influences the types of

knowledge researchers seek and how they interpret collected evidence.

A research paradigm refers to a community's shared research perspective, encompassing assumptions, concepts, and values. In design research, paradigms play a critical role in guiding research planning, method selection, and data interpretation.

2. Dimensions of Research Paradigms

The paradigm of design research refers to a collection of widely accepted theoretical frameworks, methodologies, and processes within the discipline. It embodies the collective consensus of the design community regarding approaches to research, practice, and evaluation. A design research paradigm encompasses theoretical assumptions, value orientations, objectives, methodological tools, design processes, professional roles, as well as knowledge systems and research outcomes. As Thomas Kuhn conceptualized scientific development through periodic paradigm shifts, the paradigm of design research is not static but rather continuously evolves and expands in response to socio-technological and cultural transformations.

In conducting design research, adopting multi-dimensional perspectives for comprehensive investigation proves essential. This requires in-depth analysis across four critical domains: ontology, epistemology, axiology, and methodology. The ontological dimension focuses on identifying the research subject and domain boundaries to establish a solid foundation for scholarly inquiry. At the epistemological level, deliberate consideration of various research methods and theoretical frameworks becomes crucial for determining optimal investigative pathways. The axiological perspective compels researchers to examine value propositions embedded in design practices and explore their profound implications, aiming to better address societal needs and enhance collective well-being. Methodologically, meticulous evaluation guides the selection of appropriate research techniques and tools to ensure academic rigor and effectiveness. Through systematic analysis and reflection across these four dimensions, researchers can construct a comprehensive theoretical framework that provides robust conceptual support for design research.

Saunders et al. (2009) introduced the Research Onion Model (Figure 2) in their seminal work *Research Methods for Business Students*. Originally developed to elucidate various stages of business research and facilitate methodological organization, this model also serves as an effective framework for design students and researchers to comprehend design research through paradigmatic lenses.



Figure 2. Research Onion Model

Source: ©2022 Mark NK Saunders; developed from Saunders et. al. 2019.

The Research Onion Model comprises six concentric layers progressing from periphery to core: Philosophy, Approach to Theory Development, Methodological Choice, Strategy, Time Horizon, and Techniques/Procedures.

1) Philosophy

The outermost layer of Saunders' research onion model pertains to philosophical assumptions –a system of principles grounded in the researcher's worldview or epistemological stance. These assumptions are examined through two philosophical branches: ontology and epistemology. Ontology concerns the nature of reality and the fundamental understanding of what constitutes "truth" or existence. Epistemology addresses the process of acquiring valid knowledge and how humans comprehend the world.

Philosophical approaches in Saunders' Research Onion Model include:

Positivism: Posits that an objective description of the real world is possible. Knowledge is seen as objectively existent and is suitable for quantitative research.

Critical Realism: Suggests that hidden power structures support social realities, making it applicable to studies in political science and ideology.

Interpretivism: Argues that knowledge is closely tied to the researcher's values and personal experiences. In design research, interpretivism's philosophical foundation is more appropriate, inherently favoring qualitative analysis.

Postmodernism: Developed after World War II, this approach opposes granting authority, methods, and paradigms privileged status.

Pragmatism: Founded by Peirce and William James, this American philosophical movement holds that the meaning of concepts should be derived from their practical effects. The function of thought is to guide action, and the ultimate test of truth is the practical consequences of one's beliefs. Pragmatism does not adhere to a single philosophical viewpoint but selects the most suitable method for the research problem. It is well-suited for mixed-methods research and grounded theory, especially when employing abductive reasoning.

2) Approach to Theory Development

The second layer of Saunders' Research Onion Model addresses approach to theory development: *deduction, induction,* and *abduction*.

Deduction: The deductive approach begins with hypotheses derived from literature reviews. Researchers then conduct systematic testing to examine the validity of these hypotheses within specific contexts.

Induction: Inductive reasoning builds new theories from researchers' empirical observations, treating these observations as foundational evidence.

Abduction: Abductive reasoning, increasingly recognized as a distinct third approach, operates outside the traditional deductive-inductive dichotomy. It is a form of inference that starts with observed phenomena (outcomes) to hypothesize potential causes. In practice, abductive reasoning focuses on constructing plausible explanations through iterative data collection and analysis. Its conclusions are often framed as reasonable conjectures rather than definitive proofs.

3) Methodological Choice

Saunders' Research Onion Model suggests three possible approaches for conducting research: single-method, multiple-methods, and mixed-methods.

Single-Method: This approach employs only one research method, such as a single qualitative method (Mono method qualitative) or a single quantitative method (Mono method quantitative).

Multiple-Methods: This approach utilizes a broader range of methods, for example, employing more than two qualitative or quantitative methods within a single case study (Multi-method qualitative, Multi-method

quantitative).

Mixed-Methods: This approach combines two or more research methods, typically involving both qualitative and quantitative methods (Mixed method simple, Mixed method complex).

4) Strategies

Research strategy refers to the comprehensive set of techniques, assumptions, and practices used in translating theoretical paradigms into empirical reality. Researchers select strategies based on their research questions and objectives. Common strategies include but are not limited to: experiment, survey, case study, action research, grounded theory, ethnography, archival research.

5) Time Horizon

The time horizon refers to the temporal scope of the research. Typically, observations based on time horizons can be categorized into two types: cross-sectional studies and longitudinal studies.

Cross-Sectional Studies: In cross-sectional studies, data is collected by researchers at a single point in time or over a relatively short period. Data often comes from different groups or various types of individuals. Cross-sectional studies are suitable for quantitative analysis.

Longitudinal Studies: Longitudinal studies involve research conducted over time, with data collected at multiple points or intervals, often spanning a longer duration. These studies are well-suited for qualitative analysis methods.

6) Techniques and Procedures

This innermost layer of the Research Onion Model encompasses data collection techniques and methodological procedures, clarifying how and why research is conducted. At this stage, researchers make critical decisions regarding primary vs. secondary data and qualitative vs. quantitative Data.

Data serves as the foundation of the research onion framework. In the 2019 revision of the model, three additional dimensions were incorporated:

Access (negotiating entry to research sites)

Ethics (adherence to ethical guidelines)

Sampling Strategies (e.g., purposive, random, or stratified sampling)

This study adapts the Research Onion Model to propose a novel conceptual framework for design research the Research Tree Diagram. Through information visualization techniques, this dendrogrammatic model aims to provide design researchers with a structured yet flexible guidance system. Building upon Saunders' original framework, it seeks to enhance methodological clarity and operational efficiency in design research practices.

3. Construction of the Research Tree Diagram

The system of design research is conceptualized as a dynamic process comprising three interrelated activities: design theory, method and analysis. Within academic discourse, these components are respectively categorized as ontological, epistemological, and methodological dimensions. To comprehensively capture disciplinary diversity, researchers must integrate perspectives across diverse groups encompassing cultural, gender, racial, and ethnic communities throughout their investigations. Prior to formal research commencement, scholars typically establish a set of preconceived viewpoints or analytical frameworks - constituting the theoretical (ontological) foundation. These theoretical constructs subsequently determine the nature of research questions to be explored, thereby initiating epistemological inquiry. Researchers then select appropriate research paradigms to systematically analyze and deconstruct these inquiries, enabling deeper exploration of nuanced cognitive dimensions.

The construction of design research models serves dual purposes: it not only visually represents the multidimensional characteristics of design research but also facilitates more intuitive and transparent information communication through data analysis and visualization techniques. This methodological approach enhances researchers' insight into the fundamental nature and intrinsic relationships within design research, thereby strengthening comprehension and mastery of complex issues. The "Research Tree Diagram" (Figure 3) developed in this study synthesizes widely accepted theoretical frameworks, methodologies, and procedural systems within design research. The model adopts a bifurcated structure: the canopy section elucidates multidimensional aspects of design research paradigms, while the root system reveals design discipline's profound interdisciplinary influences across academic domains. This arboreal metaphor effectively demonstrates both the endogenous development of design research and its extensive disciplinary permeation.



Figure 3. Research Tree Diagram

3.1. Roots of the Research Tree Diagram

Design, as an interdisciplinary field, draws foundational influences from multiple disciplines:

- 1) Arts & Aesthetics: Incorporates artistic methodologies and aesthetic principles.
- 2) **Engineering**: Adopts technical approaches to ensure product functionality and feasibility.
- 3) **Sociology & Anthropology**: Utilizes cultural and social behavioral studies to understand user demographics and market dynamics.

- 4) **Psychology**: Applies psychological principles to decode user needs and inform human-centered design.
- 5) **Cognitive Science**: Optimizes cognitive processes to enhance user experience.
- 6) **Business Studies**: Integrates marketing strategies and brand management.
- 7) **Computer Science**: Converges with technological advancements in interactive and interface design.
- 8) Environmental Science: Embeds sustainable development principles in design practices.
- 9) Human-Computer Interaction (HCI): Bridges computational technologies with user-centered design.
- 10) Philosophy: Informs design ethics, ontological inquiries, and epistemological frameworks.

3.2. Canopy of the Research Tree Diagram

The canopy of the Research Tree Diagram delineates the stratified dimensions of design research paradigms across five levels: ontology, epistemology, methodology, approach to theory development, strategy, and datasample-ethics considerations. By referencing the Research Onion Model discussed earlier, this framework provides systematic clarity regarding research processes and methodological architectures. The construction of this Research Tree Diagram adapts and extends the Research Onion Model, refining its structure to address design-specific characteristics as elaborated below:

3.2.1. Ontology

As the foundational stratum of the Research Tree Diagram, ontology is defined by the *Oxford English Dictionary* as the science of being or existence, or a branch of metaphysics concerned with the nature and relations of being. As a philosophical concept, ontology focuses on interrogating the essence of existence. Despite divergent interpretations across disciplines, the definition proposed by Gruber at Stanford University—which posits ontology as "an explicit specification of conceptualizations"—has gained broad scholarly acceptance (Gruber1995," n.d.)Broadly, ontology investigates the ultimate nature of reality, whose comprehension is inherently mediated through epistemological frameworks. In essence, ontology examines *what constitutes the fundamental nature of things*, while epistemology explores *how such knowledge is acquired*. These complementary philosophical constructs jointly form the bedrock of design methodology.

As the cornerstone of philosophical inquiry, ontology profoundly shapes human understanding of reality. It continuously guides cognitive processes, particularly when encountering novel phenomena or knowledge systems, by providing frameworks to assimilate and interpret emergent information. The ontological pursuit seeks to answer the primordial question: "What is the true nature of reality?" Within design studies, ontology establishes a robust theoretical foundation through philosophical analysis, advancing comprehension of how design influences socio-conceptual transformations via diverse practices and theoretical pathways. Design-oriented ontological inquiry addresses fundamental questions: "What constitutes the essence of design?" and "How are elements organized within design praxis?" The application of ontology in design research enables rigorous exploration of design artifacts—whether products, services, or systems—by interrogating their existential modes and functional logics. Furthermore, it examines the designer's role as a meaning-maker, analyzing problem-solving mechanisms, semantic constructions, and the tangible impacts of design interventions on material and socio-cultural realities.

3.2.2. Epistemology

As the secondary stratum of the Research Tree Diagram, epistemology plays a pivotal role in design research and practice by interrogating the genesis, validation, and accumulation of knowledge. Epistemological inquiry in design research focuses on elucidating how knowledge about design is acquired, interpreted, and substantiated, while critically examining nature, generation, and verification processes of design knowledge. Epistemology, ontologically grounded, constitutes the philosophical lens through which we investigate reality. Its expansive theoretical spectrum encompasses multiple paradigms—including interpretivism, positivism, postpositivism, pragmatism, postmodernism, and constructivism—each contributing distinct philosophical foundations to design scholarship. Among these, the constructivist paradigm posits reality as socially constructed through individual or collective interactions, prioritizing the interpretation of complex human behaviors. Post-positivism, conversely, acknowledges the partial objectivity of world descriptions, recognizing inherent limitations in all methodological approaches.

Termed the "theory of knowledge," epistemology classifies knowledge origins into two primary domains: empirical experience and rational reasoning. As articulated by Johnson and Christensen (2019, Redfield et al. 2010), empiricism asserts that all knowledge derives from sensory experience. This philosophical doctrine regards observable phenomena as the basis of truth, emphasizing systematic observation as the primary mode of investigating reality. Human cognition is fundamentally shaped by sociocultural influences—familial, educational, institutional, mediatic, and religious—which collectively serve as reservoirs of knowledge while critically informing worldview and value formation. Through the assimilation of societal customs, traditions, and belief systems, individuals progressively construct personalized cognitive frameworks, ultimately developing unique behavioral principles and epistemic convictions about the world.

3.2.3. Approach to Theory Development

Theoretical development approaches constitute the third stratum of the Research Tree Diagram. Rooted in rationalism—a philosophical tradition positing that truth can be derived independently of empirical observation— these approaches operationalize three reasoning paradigms: deduction, induction, and abduction.

1. Deductive Reasoning:

Initiates with hypotheses distilled from literature reviews

Progresses through systematic experimentation to validate hypothesis applicability in specific contexts

2. Inductive Reasoning:

Grounds theoretical construction in observed phenomena Transforms empirical findings into foundational principles for novel theories

3. Abductive Reasoning:

Emerges as a distinct third paradigm diverging from deductive-inductive binaries Commences with observed outcomes to infer plausible causal explanations Prioritizes hypothesis formulation through iterative data collection and analysis, yielding probabilistically grounded conclusions

Table 1 systematically compares these three approaches across four analytical dimensions: logical coherence, generalizability, data utilization patterns, and theoretical underpinnings. Philosophically, deductive reasoning aligns with positivist and post-positivist frameworks. Inductive reasoning, while predominantly associated with interpretivist traditions due to its emphasis on subjective interpretation and humanistic inquiry, exhibits broader philosophical affiliations. Abductive reasoning derives its epistemological legitimacy from critical realism, postmodernism, and pragmatism.

Type of Reasoning	Deductive Reasoning	Inductive Reasoning Abductive Reasoning	
Logical Coherence	True premises ensure a	Using known premises to	Using known premises to
	true conclusion	generate untested	generate testable
		conclusions	conclusions
Generalizability	General \rightarrow Specific	Specific → General	Interaction of
			Specific/General
Data Utilization	Data collection assesses	Data collection explores	Data collection explores
Patterns	hypotheses linked to	phenomena, identifies	phenomena, identifies
	existing theories	patterns, and builds	patterns, integrates them
		conceptual frameworks	into frameworks, and tests
			via further collection.
Theory	Falsification/verification	Theory generation	Theory
			modification/creation

Table	1.	Compares	these	approaches
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3.2.4. Methodology

As the fourth dimension in the study of the Design Tree Diagrams, methodology plays a crucial role in design research. For novice researchers, methods and methodology are often conflated. While related, these two concepts carry distinct meanings. Methodology refers to the theoretical framework of methods, representing the overarching approach or pathway for accomplishing research objectives. It constitutes a systematic discipline encompassing scientific principles, norms, and procedural techniques, covering all stages from problem definition and data collection to analysis and presentation of findings. In design research, methodology focuses on the logical and philosophical foundations underlying the design process, typically addressing how to conduct systematic and structured inquiries within the design domain to generate knowledge, propose solutions, or test concepts.

Design research methodology involves both the logic of investigative processes and the philosophical underpinnings of research. Key issues explored in design research methodology include: 1) the nature of design phenomena and their interpretation; 2) philosophical foundations and assumptions in design research; 3) the objectivity of research outcomes; 4) the relationship between researchers' values and investigations; 5) diverse paradigms and their applications in design research; 6) the inherent logic of different research approaches.

Regarding research modes, design research extends beyond conventional qualitative, quantitative, and mixedmethods approaches to include user-centered research and participatory methodologies.

The five methodological dimensions mentioned above are detailed as follows:

1) Qualitative Research

Denzin et al. (2018) emphasize that the term "qualitative" underscores the examination of qualities, processes, and meanings that resist reduction to numerical values, quantities, intensities, or frequencies. Qualitative research constitutes a research approach primarily concerned with describing and understanding human or social phenomena within natural contexts.

In design research, qualitative methods enable researchers to decode user behaviors, needs, motivations, and interactive patterns with products, services, or systems. These approaches employ analytical techniques including in-depth interviews, focus groups, case studies, ethnographic research, qualitative content analysis, and thematic analysis to interpret textual or observational data. For instance, in studying age-friendly services, in-depth interviews with elderly users may reveal how such facilities influence their daily lives. Through verbatim accounts, researchers can identify emergent themes regarding service accessibility, perceived value, and

sociocultural impacts.

2) Quantitative Methods Research

Quantitative research constitutes a scientific method emphasizing mathematical and statistical tools to quantify phenomena, test hypotheses, and establish theoretical relationships. Its objectives typically involve measuring variable correlations, comparing group differences, or determining causal relationships. This approach yields precise, data-driven conclusions, particularly suitable for hypothesis testing in large-scale studies requiring generalizable outcomes. Widely adopted across natural sciences, social sciences, economics, psychology, and design disciplines, quantitative methods remain indispensable in empirical inquiry.

In design research applications—continuing the age-friendly services example—quantitative investigations might focus on:

Usage metrics: Number of elderly users, service adoption rates

Infrastructure quantification: Facility types, spatial distribution, and quality indices

Hypothesis validation: Statistical testing of service effectiveness (e.g., improved convenience metrics)

Comparative analysis: Benchmarking outcomes against control groups lacking service access

3) Mixed Methods Research

Mixed methods research constitutes a methodological strategy that systematically integrates quantitative and qualitative research approaches. As noted by Oswald (2010), the non-exclusive relationship between qualitative and quantitative paradigms forms the philosophical cornerstone of contemporary mixed methods discourse. This method has evolved over three decades as a distinct research tradition.

Creswell (2021) defines mixed methods as: An approach to inquiry in social, behavioral, and health sciences where researchers collect both quantitative (closed-ended) and qualitative (open-ended) data, integrate the two forms of evidence, and interpret findings through their combined strengths to comprehensively address research questions. This method operates on the premise that synergistic integration of quantitative and qualitative data yields deeper explanatory power than either approach alone. Its adoption in design studies reflects growing recognition of its capacity to address complex, multidimensional research problems through methodological triangulation.

Mixed methods research does not merely involve the collection of qualitative and quantitative data; it encompasses the gathering, analysis, and integration of both quantitative and qualitative data to address research questions comprehensively. This approach requires collecting and analyzing both types of data specifically tailored to the research question at hand. It involves using particular types of mixed-methods designs to either combine or integrate quantitative and qualitative data, followed by an interpretation of this integration. Specific mixed-methods designs include, but are not limited to: Convergent Design, Explanatory Sequential Design, Exploratory Sequential Design.

Convergent Design

Also termed *concurrent parallel design*, this approach involves the simultaneous collection and analysis of quantitative and qualitative data, followed by systematic comparison of analytical outcomes (often to validate one dataset through another). Its objectives are twofold:

- Reliability enhancement: Strengthening research validity through multimodal verification
- **Triangulation**: Employing methodological triangulation to rigorously interrogate research questions and findings

Explanatory Sequential Design

This design adopts a phased implementation:

• Initial quantitative phase: Collection and statistical analysis of quantitative data.

• **Subsequent qualitative phase:** Subsequent qualitative phase: Targeted qualitative data collection aimed at contextualizing and interpreting the quantitative results. Characterized by its operational simplicity, this design supports clear causal inference through iterative explanatory processes.

Exploratory Sequential Design

- Initially, qualitative research is conducted to explore the subject area, followed by the collection of quantitative data. This approach enables researchers to develop measurement tools based on qualitative findings and subsequently validate these instruments through quantitative research.
- For example, Hou et al. (2002, 2005) in their cervical cancer screening project in Taiwan, first identified key factors influencing Pap screening uptake through qualitative interviews. Based on these variables, they developed a questionnaire and used quantitative methods to investigate relationships between these factors and screening behaviors.

In general, mixed methods research is underpinned by a pluralistic research perspective characterized by openness, which encourages researchers to flexibly select and employ diverse research methodologies based on the nature of the research problem, thereby deepening comprehension. Researchers posit that this approach facilitates the achievement of more comprehensive and objective research outcomes.

4) User-Centered Design

User-centered research is centered around the needs and experiences of users, emphasizing user involvement, contextual inquiry, prototype testing, and usability evaluation. Its primary objectives are to enhance user satisfaction and loyalty while ensuring the market success of products or services. This approach typically integrates qualitative and quantitative methods to gather user data, which is then systematically applied to guide the entire design and development process.

5) Co-creation and Participation

Co-creation and participation in design research aims to bring together users, stakeholders, and development teams to collaboratively refine and improve products, services, or systems. This approach prioritizes active collaboration with users, stakeholders, and fellow designers, often implemented through co-creation workshops, group discussions, and similar participatory formats. The co-creation process values the expertise and experiential insights of all participants, recognizing that diverse stakeholders contribute unique and valuable perspectives to inform and enrich the design process.

3.2.5. Research Strategies

Research strategies refer to the techniques, hypotheses, implementations, and analytical approaches employed in a study. These strategies guide researchers in transitioning from theoretical paradigms to actionable research designs, enabling the systematic collection of data. Common research strategies include case studies, grounded theory, content analysis, thematic analysis, ethnography, phenomenology, participatory observation, interviews, and more.

Each strategy is inherently linked to specific data collection methods. For example, qualitative content analysis relies on interviews and textual analysis. The selection of appropriate data collection methods depends on a comprehensive evaluation of the research objectives, questions, and available resources. Properly aligned methods not only provide robust evidentiary support for subsequent data analysis but also enable in-depth exploration and validation of research questions.

Moreover, well-chosen data collection methods can contribute to the generation of design theories or research frameworks, offering actionable guidance for design research or practice. For instance, in sustainable design

research, interviews and textual analysis can reveal public perceptions and behavioral patterns toward sustainability strategies, informing the development of more effective sustainable design interventions. Similarly, in market research, interviews and textual analysis help uncover consumer needs and expectations for specific products, thereby guiding product design and marketing strategies.

In summary, aligning data collection methods with research strategies is a critical step in the research process. This alignment ensures rigorous evidence-based inquiry, validates theoretical assumptions, and may even generate novel theories or frameworks to advance research and practice.

3.2.6. Data, Sampling, and Ethics

This phase encompasses data collection, sampling strategies, and ethical considerations. In design research, effective data collection prioritizes not only quantitative data (e.g., survey results and statistical metrics) but equally values qualitative data, such as participants' personal experiences, stories, and insights.

There are various methods for selecting samples, including *random sampling*, *quota sampling*, *convenience sampling*, *snowball sampling*, *purposive sampling*, and *judgmental sampling*. The selection of an appropriate method depends on the research questions, methodological design, and resource availability. To ensure representativeness, samples should reflect the multidimensional nature of the research topic. For instance, in a study on age-friendly home modifications, researchers would strategically engage stakeholders directly involved in the phenomenon: older adults utilizing such modifications and professionals implementing renovation projects.

Ethical compliance is imperative throughout sampling and data handling. Researchers must:

Ensure procedural fairness and transparency in participant selection

Obtain informed consent by clearly communicating research objectives, risks, and benefits

Maintain confidentiality through data anonymization (e.g., de-identification and removal of personally identifiable references)

Respect cultural protocols in cross-cultural studies by aligning practices with local norms and customary practices

In summary, the process of data collection and sample selection must be carefully planned and ethically conducted. Ensuring diversity and representativeness in the sample helps to capture a comprehensive understanding of the research problem. Ethical considerations, including informed consent, confidentiality, and cultural sensitivity, are paramount throughout the research process to uphold integrity and trustworthiness.

4. Application of Design Tree Diagram

4.1. Case Study

This research proposal aims to systematically demonstrate the various steps involved in conducting design research using a case study approach based on a design project, with a particular focus on the application of the Research Tree Diagram.

As the field of design research continues to evolve, researchers are increasingly recognizing the importance of structuring and visualizing complex research processes to enhance the understanding and communication of research findings. The Research Tree Diagram serves as an effective tool that assists researchers in presenting their research objectives, questions, methods, and results in a hierarchical and organized manner. Consequently, this method improves the transparency and traceability of the research process, ensuring that each step is clearly articulated and easily followed.

By utilizing the Research Tree Diagram, this proposal seeks to provide a structured framework for navigating the complexities of design research, thereby facilitating more coherent and comprehensive studies.

4.1.1. Project Overview

This study centers on Yanqian Village, targeting left-behind elderly residents aged 65 and above to investigate age-friendly home care service strategies. Yanqian Village, located in the southern region of Anyuan Township, Ninghua County, Fujian Province, comprises six natural villages and 13 production groups, totaling 386 households. Accelerated urbanization has driven significant youth migration to urban areas, resulting in a growing population of left-behind elderly. To address this challenge, researchers collaborated with the Fujian Provincial Rural Revitalization Development Team and XXX Cultural Development Co., Ltd. of Yanqian Town to initiate a home renovation project tailored to the needs of elderly residents.

4.1.2. Research Plan Development

Under the title "Age-Friendly Rural Service Design Based on Social Innovation: A Case Study of Yanqian Village ", the research plan was formulated utilizing a Design Tree Diagram. Key components are outlined as follows:

- 1. Thematic Focus: The study anchors its inquiry on social innovation-driven rural age-friendly service design.
- 2. Philosophical Paradigm: Adopts an interpretivist philosophical paradigm to emphasize contextual and value-laden understandings of elderly needs.
- 3. Methodological Pathway:

Employs inductive reasoning to derive theory from qualitative data.

Utilizes ethnographic strategies to conduct an in-depth case study of service design improvements in Yanqian Village.

Literature Review Structure

Following thematic clarification, the review synthesizes existing scholarship across two dimensions:

1. Age-Friendly services: Theoretical foundations

Understanding age-friendly services: Definitions and core concepts

Guiding principles and methodologies: Approaches to implementing age-friendly services

2. Social innovation: Theoretical perspectives

Defining social innovation: Key concepts and insights

Rural development applications: Utilizing social innovation in rural contexts

The schematic organization of this review is illustrated in Figure 4:





Research Ethics

This study adheres to ethical principles, prioritizing privacy protection, participant dignity, and compliance with ethical review protocols. All villagers (participants) involved in surveys and interviews signed informed consent forms, explicitly confirming their voluntary participation and granting permission for researchers to collect and utilize provided data. Researchers assured participants that no personally identifiable information would be disclosed in research outputs without explicit consent. Participants retained full autonomy to withdraw from the study at any stage without consequence.

Research Design

The research design encompasses several key components, including an introduction, research objectives, research questions, and the methodologies employed.

Introduction: This section provides an overview of Yanqian Village's geographical location and economic profile, demographic structure, and the current state of aging. It summarizes the existing age-friendly services in Yanqian Village and identifies the challenges present in home-based elderly care services. The analysis will focus on the needs of the elderly population, highlighting the discrepancies between these needs and the available services, and emphasizing the significance of social innovation in enhancing age-friendly service design for this group. A brief overview of significant studies in the fields of age-friendly services and social innovation is provided to contextualize the research within the broader academic discourse.

Research Objectives: The primary aim of this study is to develop and refine the implementation and evaluation mechanisms for age-friendly service designs, ensuring their effectiveness and fostering continuous improvement and innovation. Ultimately, the goal is to establish a replicable and scalable model for rural age-friendly services.

Research Questions: Based on the research objectives, two types of research questions are identified: central and subsidiary.

Central Research Question: How can a comprehensive framework for age-friendly service design be constructed that is suitable for rural environments?

Subsidiary Research Questions:

- i. What are the shortcomings of existing age-friendly service designs, and what areas require improvement?
- ii. How can social innovation theories be applied to the design and implementation of age-friendly services?
- iii. How should the evaluation mechanisms for age-friendly services be designed, and what are the key indicators for assessment?

Research Approach and Methods

In the methodology section, this study employs an ethnographic strategy, utilizing semi-structured interviews and participant observation to collect qualitative data. The research participants consist of elderly individuals aged 65 and above who are receiving home-based care in Yanqian Village. The choice of this location is driven by the support and collaboration provided by the Yanqian Town government and community organizations, which facilitate more effective data collection and field observations, thereby enhancing the efficiency and efficacy of the research.

Semi-Structured Interviews: These interviews enable researchers to gain insight into daily lives, social

interactions, and needs and evaluations of age-friendly services among the elderly population. They also help in understanding the pressures faced by local villagers in caring for the elderly, as well as the perspectives and suggestions for improvement from community workers and healthcare professionals regarding existing agefriendly services.

Participant Observation: This method involves on-site observations and photography of the living environments, community activity centers, and medical facilities used by the elderly. By observing the daily lives of the elderly, researchers can document the usage and issues related to age-friendly service facilities in the community, providing a comprehensive understanding of the current state and needs of age-friendly services in Yanqian Village.

Data Analysis: Qualitative analysis software will be employed to transcribe and code the data collected from interviews. This process facilitates the identification of key themes and patterns within the data.

Expected Outcomes: The anticipated results of this study include the development of age-friendly service models based on the principles of social innovation. These models should incorporate multi-stakeholder participation (including government, community, family, and volunteers), resource integration, and technological support. Additionally, the research aims to outline preliminary service frameworks and processes that can be implemented to enhance age-friendly services in rural areas.

This case study illustrates how to employ a Design Tree Diagram in design research, swiftly engaging with the research topic from three critical perspectives: ontology, epistemology, and methodology. Initially, by establishing a clear research background, the specific research objectives and questions are elaborately described. Throughout this process, particular emphasis is placed on the importance of design ethics. Subsequently, appropriate methods are employed to collect and analyze data, ensuring the rigor and validity of the research. Finally, an overview of the expected research outcomes is provided.

Through the analysis of this case, researchers can learn how to use this model to efficiently and effectively conduct design research. This approach not only aids in systematically organizing research ideas but also ensures logical clarity and goal-oriented focus at each key stage, thereby enhancing the overall quality of the research.

5. Summary

As an essential information visualization tool, the Research Tree Diagram facilitate researchers' comprehension of problem essence and intrinsic relationships by graphically presenting complex data and connections. The construction of Research Tree Diagram aims not only to guide researchers in smoothly conducting design studies but also to assist them in systematically integrating diverse relevant information and discovering novel perspectives and directions. Furthermore, the Research Tree Diagram enhances team collaboration by facilitating idea sharing and communication among team members.

The subsequent phase of this research involves applying Research Tree Diagram to more design study cases. Through collecting substantial empirical case data, we will conduct in-depth analysis and optimization of the Research Tree Diagram to improve their adaptability across various design research domains. Concurrently, targeted experimental validations will be implemented to verify the effectiveness and feasibility of the Research Tree Diagram in practical applications, thereby refining the theoretical framework. Additionally, we will actively explore cross-disciplinary collaboration opportunities with other academic fields, drawing upon their methodologies and experiences to expand potential applications and developmental prospects of research tree diagrams in design studies.

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Conflict of Interests

The author claims that the manuscript is completely original. The author also declares no conflict of interest.

Author Contributions

Conceptualization: Qinghua Yu; Investigation: Qinghua Yu; Methodology: Qinghua Yu; Formal analysis: Qinghua Yu; Writing – original draft: Qinghua Yu; Writing – review & editing: Qinghua Yu.

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