The viability of post-graduate students developing a commercial ERP system of industry standards: A South African Case Study

J. F. Du Plessis

orcid.org/placeholder

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Supervisor: Prof. C. J. Kruger

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Student number: 33642958

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I would like to thank the everyone for helping me. You're all great!

Abstract

This is the abstract. It is a summary of all the work.

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Table of abbreviations

A table containing a list of abbreviations that will be used throughout text.

ERP	Enterprise Resource Planning
CRM	Customer Relationship Management
DSR	Design Science Research
IS	Information Science
CR	Critical Realism
IS	Information Science
ADR	Action Design Research

Chapter 1

Introduction

The demand for efficient and adaptable enterprise solutions has never been greater in today's rapidly evolving technological landscape. Within the South African context, where the intersection of academia and industry holds significant promise for innovation and economic growth, the exploration of novel approaches to software development becomes imperative. This introduction outlines the rationale, objectives, and structure of the research study aimed at investigating the feasibility and efficacy of leveraging university student talent to develop a commercial-grade software solution in the form of an Enterprise Resource Planning (ERP) system in collaboration with TaskFlow a partnering North-West University-industry software development company.

Collaboration between industry and academia is essential to benefit the global technological village (Baig et al., 2018). Unfortunately, universities, especially in developing nations, often lack the resources to allow for the proper development of skills needed by students entering the software development workforce. Through collaborative initiatives, software companies possess the necessary skills, know-how, and technology to improve the skills of university students in a controlled environment that simulates real-world experience. For instance, companies specialising in software development, like TaskFlow, integrate solutions such as Contact Centre, Customer Relations Management, Dialer, and Helpdesk into a comprehensive Enterprise Resource Planning (ERP) suite. This empowers their clients to optimise time and make informed business decisions through tailor-made and integrated software that more efficiently and effectively streamlines their entire business processes.

Integrated ERP systems significantly affect the organisation's value chain in both primary and secondary operations (Amini and Abukari, 2020). By connecting business and management activities, enterprise resource planning (ERP) assists organisations in realising their full potential (Uçaktürk and Villard, 2013). Additionally, while ERP systems are pivotal to operational success, the associated expenses of non-integrated software solutions present significant barriers to cost and scalability. Consequently, many software-developing companies aim to minimise the cost of training interns on the theory behind and use of

integrated software tools, project management, and software development, especially when developing complex systems such as ERP suits. This research aims to investigate whether Higher Education Institutions (HEIs) can effectively address the current challenges faced by the industry by introducing collaborative university/industry-applied teaching to some postgraduate computer science and information systems curricula. By doing so, the study explores the viability of creating a mutually beneficial relationship between academia and industry, which can bring positive outcomes for both parties and students. As such, the research will delve into the potential of the curricula in Project management and System development at Honor's level to mitigate the challenges faced by the industry while nurturing a dynamic and symbiotic partnership between academia and industry.

1.1 Problem Statement

The intersection of academia and industry presents unique opportunities and formidable challenges. Employers find it challenging to locate people with the knowledge and abilities needed for open positions (Barnett, 2011). Former President Barack Obama thus emphasised the need for lawmakers and national higher education associations to urge educational institutions to not only set ambitious educational attainment targets but also ensure that their goals address the current gap in required industry skills Barnett (2011). Thus, creating an educational environment for efficient learning and skill development is imperative to provide the correct skills for industry (Baig et al., 2018). Therefore, it is beneficial for graduate students to comprehend how the industry operates and how idea and innovation are turned into the products and services society requires (Foley, 1997).

The central inquiry for this study emerges from the argument that tertiary education students need to be trained for the requirements of a professional workspace (Baig et al., 2018). The question arises: *To what extent can postgraduate students be effectively taught to develop industry-standard software solutions such as ERP systems amidst the multidimensional challenges of technical proficiency, client satisfaction, and academic rigour?*

1.2 Research Aims and Objectives

The upcoming study will concentrate on three primary objectives. First, it will define the essential components and prerequisites of a fully functional, versatile, and industry-approved software system. Secondly, it aims to pinpoint the critical abilities that students must possess to create an acceptable software system in the industry. Lastly, it will explore the roles of academia and industry in facilitating the successful creation of such a system through sound project management and system development skills.

This study aims to evaluate the feasibility of creating a commercially viable software solution in collaboration with a software development company as part of the NWU com-

puter science and information systems department's prescribed curriculum on IT project management and software development honours program. Through collaboration with the industry, this study aims to showcase the technical abilities of computer science students by developing a software solution that meets commercial standards. This initiative also seeks to equip students with the necessary skills to become valuable contributors to the South African workforce. The project aims to conduct a pilot study to identify the key success factors in guiding postgraduate students at a Higher Education Institution (HEI) in an underdeveloped country. The goal is to provide these students with industry exposure in a formalised academic and learning environment, enabling them to develop economically viable software. The study seeks to determine how the students can be effectively mentored and trained and what support and resources are necessary to ensure their success. Ultimately, the findings of this study will be used to inform the design of future programs that seek to foster innovation and economic growth in underdeveloped regions of the world.

This study explores the possibility of integrating projects and software development techniques taught in an educational setting by teaching existing structures and practices of a typical software development company in the South African industry. The objective is, therefore, to teach computer science and information systems graduates to identify market opportunities and, by applying industry practices and sound PM and SD methods, to develop software products that are commercially viable and aligned with market demands. As such, the research seeks to uncover optimal practices and tactics that improve educational insights regarding the teaching of PM and software development procedures, integrating cutting-edge best practices from the industry. To assess the software solution's viability as a marketable product, the research will conclude through an extensive evaluation by proficient experts and professionals in the software development industry. It will also involve thoroughly examining the client's satisfaction and feedback after receiving the final system, including any concerns they may raise. This assessment will determine the critical success factors in developing commercial software, the roles of industry and academia in the learning process, and any necessary improvements to enhance the learning experience.

1.3 Hypothesis

Postgraduate computer science and information systems students can build a sophisticated software solution that is commercially viable, such as an ERP system when partnering with the expertise and resources of industry partners.

1.4 Methods of Investigation

Throughout the commencement of the research, the study will draw upon two main facets

to substantiate the claims made in the paper's conclusions: the vast amount of academic literacy available and the other experiment based data collection processes referring to the development project as the main experiment. Both of these will be outlined below to provide clarity on both matters.

1.4.1 Literature Study

To enhance the credibility, accuracy, and validity of the study, a thorough and systematic review of pertinent literature will be conducted. This will involve targeting keywords such as higher education, academia, ERP systems, software success, project management, system implementation, and commercialisation. Research will be prioritised from a positivist perspective and examine peer-reviewed articles from reliable sources such as the NWU Library, Google Scholar, IEEE Xplore, and ACM Digital Library. In addition, grey literature from trusted sources like white papers and industry reports will be considered, as this research incorporates best practices from the industry. Duplicate articles or those not meeting our eligibility criteria will not be accepted. To locate important material, references from key papers will be scrutinised and analysed for citation patterns, thus seeking advice and insights from subject matter experts. The focus will be on resources published between 2015 and 2024 to ensure relevance. Historical research to be focused on include:

- Njanka, S. Q., Sandula, G., and Colomo-Palacios, R. (2021). It-business alignment: A systematic literature review. Procedia Computer Science, 181:333–340.

- Kenge, R. and Khan, Z. (2020). A research study on the erp system implementation and current trends in erp. Shanlax International Journal of Management, 8(2):34–39.

- Guo Chao Alex, P. and Chirag, G. o. C. I. S. (2014). Cloud erp: a new dilemma to modern organisations? Journal of Computer Information Systems, 54(4):22–30.

- Bagchi-Sen, S., Baines, N., and Smith, H. L. (2022). Characteristics and outputs of univer- sity spin-offs in the united kingdom. International Regional Science Review, 45(6):606– 635.

1.4.2 Methods of Investigation

As mentioned earlier, this study aims to thoroughly examine the literature on software systems and student development of software in developed nations to identify applicable lessons for developing environments like South Africa. A key objective is to equip students with the knowledge needed in PM and system development to create software that adheres to industry best practices. To achieve this, the study will assess the business case for higher educational institutions to develop commercially viable software for the

industry as potential clients. Once the need is established, the next step will be identifying the technological and functional requirements for creating software that real-world clients can use to support their daily operations. Once the software is completed, the study will evaluate the usability of the software as well as the learning experience and the proficiency of postgraduate students in applying project management and systems development methodologies to complex software development. The aim is to offer significant and insightful knowledge that can be utilised by higher education institutions (HEIs) in underdeveloped countries to improve the functionality, efficiency, and acceptance of their software and systems development projects. This will help HEIs teach the most relevant and useful theories of project management and teamwork, ultimately enhancing their students employability and marketability in the industry.

As such, the researcher will serve as an integral part of the project, overseeing software development. As mentioned, according to set project management milestones, the software system will undergo testing by reviewers with experience in the information technology and ERP industries. All lessons learned and the input from reviewers will be compiled to produce a workable framework that can direct HEIs in leveraging project management and software development curricula to develop commercially viable software solutions and systems for internal and industry applications.

1.5 Chapter Division

This thesis is structured into six main chapters, each meticulously crafted to delve into specific facets of the research endeavour, elucidating methodologies, literature insights, empirical findings, and concluding reflections. The chapters are as follows:

The Research Design chapter serves as the foundational cornerstone of the thesis, this chapter provides a detailed exposition of the research methodology and paradigm guiding the study. Adopting a design science research methodology and a positivist paradigm, this section navigates the theoretical underpinnings of the research approach, outlining its epistemological and ontological foundations. Through meticulous delineation of research methods, including data collection techniques, sampling strategies, and analytical frameworks, this chapter lays the groundwork for subsequent empirical inquiry. Once this chapter has concluded, a review of the current literature in the field will be done to pinpoint previous scientific findings that will benefit the current study.

The Literature Study chapter embarks on an immersive journey through the annals of academic literature, traversing diverse domains ranging from ERP systems to implementation frameworks. The section unfolds with a lucid articulation of the problem statement, contextualising the research within the broader academic discourse. Subsequent sections delve into the intricacies of ERP systems, exploring their architectural nuances, functional capabilities, and strategic significance within organisational contexts. Furthermore, the chapter probes into the value chain framework, dissecting the interconnected dynam-

ics of people, processes, and technology in driving organisational success. Anchored by comprehensive reviews of commercialization strategies, software implementation frameworks, and the role of students in industry, this chapter serves as a beacon of scholarly inquiry, illuminating the theoretical landscape underpinning the research endeavor. Once the theoretical landscape has been illuminated, a case study can be conducted to generate findings regarding the research question, and help the research endeavour edge closer to final conclusion.

The Case Study embarks on a voyage of empirical exploration, this chapter unfurls the intricacies of the case study conducted within the hallowed confines of TaskFlow. With a keen focus on project design and execution, this section unveils the methodological blueprint guiding the project life cycle. Through an exhaustive examination of project management methodologies, agile development frameworks, and strategic planning processes, this chapter offers unparalleled insights into the operational dynamics underpinning software development endeavours. Furthermore, by delineating the project pipeline and process, this section charts the trajectory of the project's evolution, elucidating key milestones, challenges encountered, and lessons learned along the way. Once the case study has concluded, and sufficient data is collected around the subject at hand, an expert reviewer will reveal the depth of the truth within the findings and help the project reach its final conclusion.

In pursuit of academic rigour and scholarly validation, the Expert Reviewer chapter invites the discerning gaze of domain experts to scrutinise the research methodology and findings. Through structured interviews, expert assessments, and critical appraisals, this section seeks to engender a dialectic discourse, fostering intellectual exchange and epistemic enrichment. By subjecting the research endeavour to rigorous scrutiny, this chapter endeavours to enhance the robustness and validity of the research findings, ensuring their salience and applicability within the broader academic community. The chapter that follows will discuss the results that were found throughout the study.

The Results and Discussion serves as the crucible of empirical inquiry, this chapter presents and analyses the empirical findings gleaned from the case study and expert review. Through meticulous data analysis techniques, including qualitative coding, thematic analysis, and comparative synthesis, this section unveils the rich tapestry of insights garnered from the research endeavour. Furthermore, by fostering a dialectic discourse between empirical findings and theoretical frameworks, this chapter endeavours to unravel the underlying mechanisms and causal relationships shaping the research phenomena. The chapter that follows will make the final conclusions regarding the total study and its findings; it will act as a summary for the research project and summarise the findings to draw the final conclusion.

The conclusions chapter aims to synthesise key insights, implications, and avenues for future research, this chapter offers a reflective denouement to the research endeavour. Through a judicious synthesis of empirical findings and theoretical frameworks, this section

distils the essence of the research inquiry, elucidating its broader implications and relevance within academic and practical contexts. Furthermore, by delineating avenues for future research and scholarly inquiry, this chapter seeks to catalyse intellectual curiosity and foster a culture of continuous learning and innovation.

In summation, this research endeavour represents a concerted effort to bridge the gap between academic theory and industrial practice, laying the foundation for the subsequent chapter, "Research Design." By elucidating the theoretical underpinnings and methodological frameworks guiding the study, the forthcoming chapter endeavors to translate lofty aspirations into tangible research methodologies, fostering innovation, collaboration, and economic prosperity within the South African software development landscape.

Chapter 2

Research Design

This chapter outlines the research design employed to in the study. The aim is to investigate and reveal the most optimal research methodology and paradigm that encourage the success of the case study. The methodology encompasses Design Science Research (DSR) within the positivist paradigm, emphasising the creation and evaluation of innovative artefacts to address specific challenges. Data collection will primarily involve monitoring a case study, supplemented by interviews with experts, with analysis conducted through quantitative methods.

The following chapter will explore and pinpoint areas of relevance to the study within the domain of research design. The chapter begins by examining various research methodologies relevant to the field and discussing the chosen methodology to be used in greater depth, addressing the relevant literature and the effect these findings will have on the research project at hand. The same exploration is then done on research paradigms and which will be most suitable and fitting for the current study, concurrently addressing the affect the choice will have on the research project. The chapter then continues to delve into methodologies for determining the success of completion of the artefact and makes use of that information to determine what data collection will be done so that a quantitative conclusion can be made at the end of the study. The rest of the chapter defines how the research is designed and how it will be conducted, as well as how ethical clearance is acquired and what ethical implications the project could have.

2.1 Exploring Research Methods using the Research Onion

When doing research, the research onion created by Saunders et al. (2009) is frequently used as a design guide. A growing number of researchers from different disciplines are increasingly embracing the research onion model as a basis for their study design, despite its original primary use in business research. The layers of the research onion represent several aspects of formulating a research strategy, the outer layers are more theoretical

and the interior levels more practical (Saunders et al., 2009). The figure below shows the research onion that was outlined by Saunders et al. (2009).
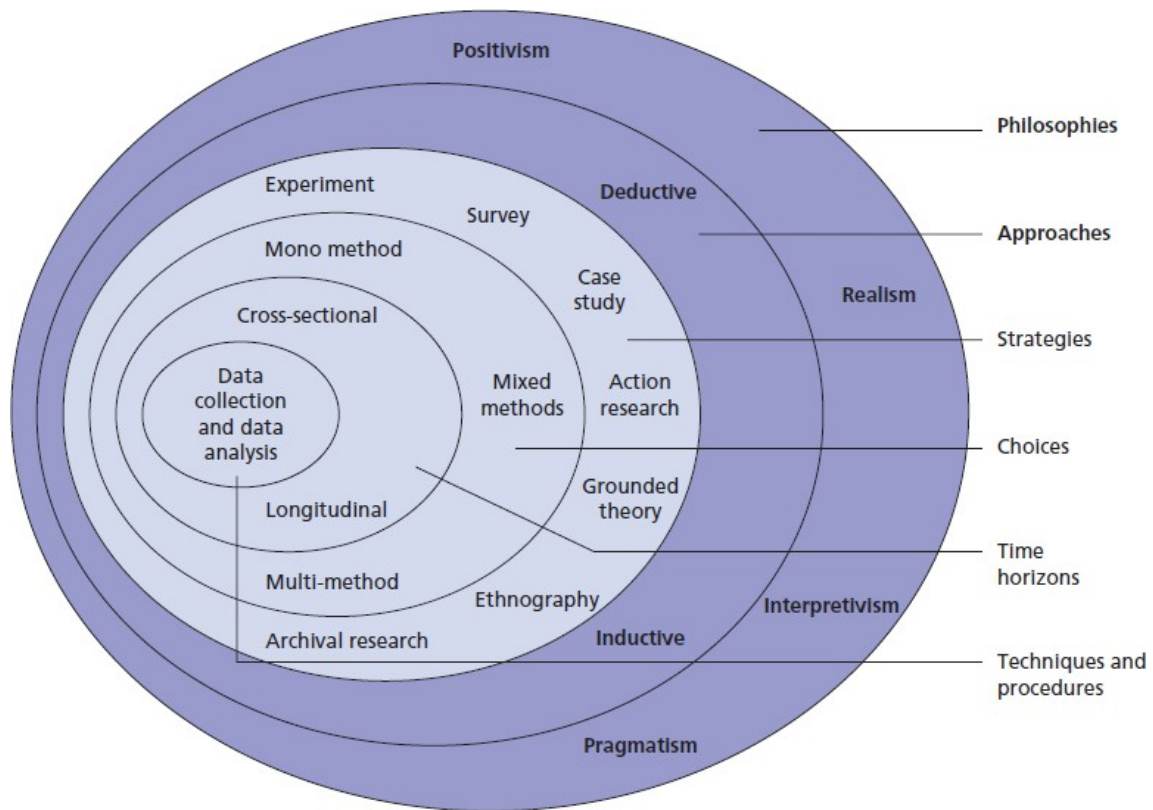
Figure 2.1: The Saunders Research Onion

Since IS is a field of study that integrates both the natural and social sciences, employing the research onion as proposed by Saunders et al. (2009) in and of itself requires some adjustments as it has not yet taken into account all the techniques and strategies used in the field of IS. Therefore, Mardiana (2020) proposed a modified version of the research onion that is more catered towards the field of information science research. The modified version of the research onion can be seen in the figure below.
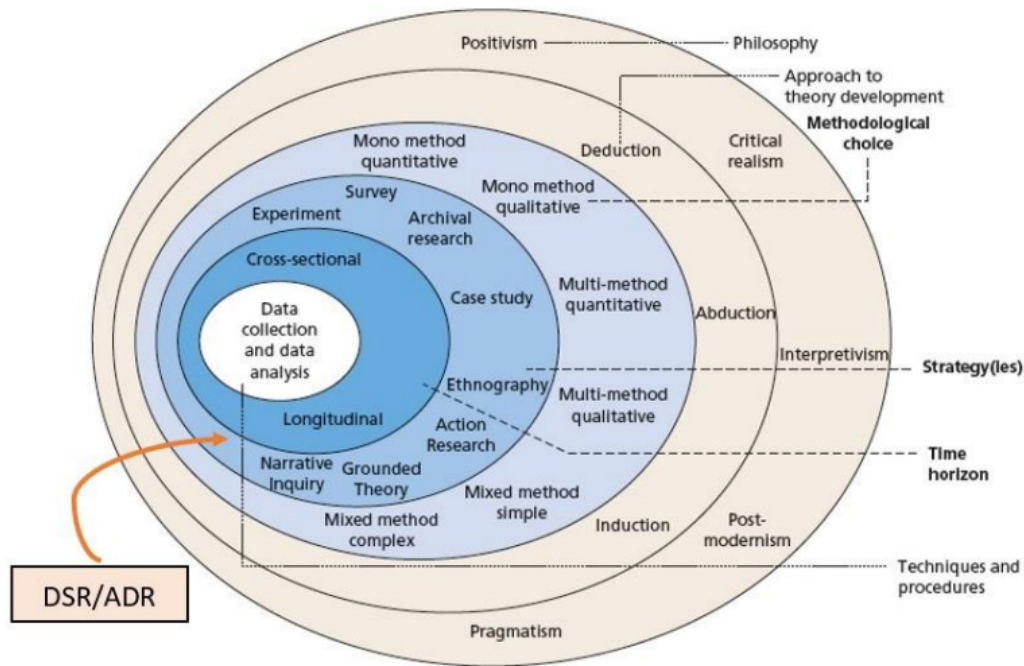
Figure 2.2: The Modified Research Onion

As it is some what difficult to understand the implications of the modified research onion, Mardiana (2020) also provides the following table showing how research design can be constructed by making use of the modified research onion.

Philosophy	Approach	Methods	Strategy	Time horizon	Data collected
Positivism	Deductive	Quantitative	Experiment	Cross-sectional Longitudinal	Numerical
Positivism	Deductive	Quantitative	Survey	Cross-sectional Longitudinal	Numerical
Interpretivism	Inductive	Qualitative	Archival research	Cross-sectional	Non-Numerical
Interpretivism	Inductive	Qualitative	Case study	Cross-sectional	Non-Numerical
Interpretivism	Inductive	Qualitative	Ethnography	Cross-sectional	Non-Numerical
Interpretivism	Inductive	Qualitative	Action Research	Cross-sectional	Non-Numerical
Positivism Interpretivism Pragmatism	Abductive Deductive	Quantitative Qualitative	Design research	Cross-sectional Longitudinal	Numerical Non-Numerical
Interpretivism	Inductive	Qualitative	Grounded theory	Cross-sectional	Non-Numerical
Interpretivism	Inductive	Qualitative	Narrative inquiry	Cross-sectional	Non-Numerical

Table 2.1: The possible research design composition in IS research

The research onion and its recommendations will be used to construct the research design that will be employed by this research project, as it provide guidelines for which options of the various components of research align with one another and are well suited. Each

component of research, namely philosophy, approach, methods, strategy, time horizon, and date collected, will be further researched and investigated throughout the rest of this chapter in order to define the complete design of the research project.

2.2 Research Philosophy

A research philosophy explains the study's methods and the type of knowledge that was produced, as well as the researcher's viewpoint on the relationship between knowledge and development. The subsections that follow outline the various philosophies that form part of the modified research onion created byMardiana (2020). Each philosophy will be studied independently in order to determine the viability of the outlook in the context of the research being conducted.

2.2.1 Positivism

Philosophers Descartes and Locke served as major influences during the 17th and 18th century Enlightenment, which is when positivism first emerged (Park et al., 2020). Over time, logical positivism also began to emerge. The idea that there is a universal, temporal truth that all disciplines must adhere to is greatly influenced by logical positivism, which holds that although scientific laws frequently emerge through the use of intuition, this does not entail that the laws can be subjectively justified (Luczak-Rösch, 2013). Moreover, logical positivism's theory of truth consists of providing a solution to the following query: "For every given statement p, what are the conditions under which p (is true) and what are the conditions under which not-p?". Therefore, "a priori" (such as mathematical axioms) and "empirical" propositions—both of which require rigorous and open validation—are central to the logic of positivism (Luczak-Rösch, 2013). Positivism, which is frequently connected to experiments and quantitative research, is seen as an evolution or kind of empiricism (Potrac et al., 2014) Essentially, positivism comes down to the following: reliable findings can only come from occurrences that can be observed, and the researcher has no control over the findings of the investigation. Therefore, the researcher has no control over the study's outcomes.

The philosophical position of positivism is based on natural scientists' use of observed reality in society to generate generalisations. Positive thinking emphasises the value of information in general and places a stronger emphasis on considering facts and pure data free from human bias or interpretation (Saunders et al., 2009). If a researcher were to embrace an extreme positivist standpoint, several consequences would ensue (Alharahsheh and Pius, 2020):

- The researcher would regard organisations or other related social entities as tangible entities, akin to physical objects and natural phenomena.

- Epistemologically, the research focus would prioritise the identification of observable and quantifiable facts or patterns. Moreover, the phenomena subjected to observation and measurement should contribute to the establishment of credibility and significance in the collected data.

- The researcher's objective would be to uncover causal relationships among the gathered data, facilitating the formulation of law-like generalisations akin to those formulated by scientists. Additionally, the researcher would utilise and incorporate fundamental universal principles and laws to justify and elucidate the behaviour or events studied within organizations.

Based on the requirements of the research project and its nature, the positivist philosophy could apply, but may not be precisely accurate and relevant for the desired outcome and intended motivation and strategy.

2.2.2 Critical Realism

A crucial component of the formation of our natural and social world, according to CR, are the structures and mechanisms that give rise to events and discourses. The main reason for the development of critical realism was to address the positivist crisis (Carlsson, 2003). Critical realism is based on a widely liberating axiology, an inclusive realist/interpretivist epistemology, and a transcendent realist ontology. Despite being a relatively new viewpoint, critical realism is being adopted by many academic sectors such as information technology (Easton, 2010). Importantly, information sciences is the main focus of this study and Wikgren (2005) has done notable research in this field. According to CR theory, it is crucial to make the clearest possible distinction between human action and socio-cultural structuring when examining human information in context. Individuals' motivations, intentions, and plans, which determine their actions, may differ greatly from the characteristics held by the social and cultural forms (the organisations, processes, jobs, and daily circumstances) that govern information activities (Wikgren, 2005).

Critical realism emerged as a response to the crisis within positivism, with Roy Bhaskar's seminal work "A Realist Theory of Science" in 1975, which was later reiterated, introducing the concept of "transcendental realism". Bhaskar (2013) further elaborated on this foundation in "Possibility of Naturalism," where he applied his ideas specifically to the social sciences, formulating what he termed "critical naturalism." These foundational texts laid the groundwork for what would later become known as "critical realism," a term Bhaskar himself adopted. Throughout the 1980s, Bhaskar continued to refine his philosophical stance, engaging in rigorous debate and argumentation. Concurrently, other scholars within the critical realism framework, such as Archer (2013) with her work "Social Origins of Educational Systems" and Sayer (1992) with "Method in Social Science", made significant contributions, enriching the discourse. Initially directed towards critiquing positivism, critical realism evolved to encompass critiques of alternative paradigms, including

postmodernism and structuration theory. As such, it stands as a comprehensive and coherent alternative to positivism and various strands of postmodern thought, offering a robust philosophical foundation for inquiry across disciplines.

Various philosophies of science hold distinct ontological perspectives. Idealism posits that reality is not independent of the mind, with different forms of idealism reflecting diverse beliefs about the nature and origin of human consciousness. In contrast, realism asserts that reality exists autonomously, irrespective of our perceptions, beliefs, or discourses. Realism, like idealism, encompasses a range of interpretations. In contemporary discourse, realism predominates among philosophies of science. According to Bhaskar (2013), the pivotal concern is not whether one subscribes to realism but rather the specific variant of realism one embraces.

This philosophy could prove to be a valuable perspective in the context of this research study. However, the remaining possibilities for research philosophies must still be investigated. Therefore, this section will proceed to conduct an investigation of the literature regarding interpretivism.

2.2.3 Interpretivism

Interpretivism shares historical roots with positivism in anthropology. But because it opposes positivism, it is sometimes referred to as anti-positivism (Flick et al., 2004). According to interpretivism, knowledge and truth are dependent on people's experiences and interpretations of them, and they are also subjective, culturally and historically placed. Since it is impossible for researchers to be totally detached from their personal values and opinions, these factors will always influence how they gather, evaluate, and analyse evidence (Ryan, 2018).

Through criticism of positivism from a subjective standpoint, interpretivism emerged. Interpretivism focuses more on the intricate details and context-related variables; it views people as distinct from physical phenomena since they are capable of generating deeper meanings and cannot be studied in the same manner as physical phenomena. As a result, research in the social sciences must be distinguished from research in the natural sciences (Alharahsheh and Pius, 2020). Here are some variations of interpretivism based on Littlejohn and Foss (2009).

- Interpretation and comprehension of philosophy are referred to as hermeneutics. Biblical sources and wisdom writings are its primary areas of focus.

- Phenomenology: This approach uses firsthand observation of phenomena to try and explain the world.

- Symbolic interactionism is a theory that views symbols as communal objects that provide meaning. In light of this, it is thought that symbols offer tools to aid in the formation of reality.

As was previously mentioned, positivist research philosophy subverts interpretivism, which is more appreciative of individual views and ideas. However, interpretive research has its detractors since it rejects and questions the validity of knowledge that has been produced as a basis and that is accepted as a universal norm. It also needs criteria that are different from those employed in positivist research (Alharahsheh and Pius, 2020). This option is not necessarily the strongest candidate for a chosen research philosophy; however, it must be investigated. The next methodology to be researched is pragmatism; its roots and ideas are discussed below.

2.2.4 Pragmatism

While interpretivism and qualitative research are often associated, there are alternative approaches as well. Along with critical research and sometimes positivism, pragmatist paradigms can also be used in information systems qualitative research. Proactive learning, intervention, and action are associated with this paradigm (Goldkuhl, 2012). According to pragmatics, the research issue is the primary factor in determining which epistemology, ontology, and axiology you choose to use—one may be more relevant than the other for addressing a certain question. Furthermore, the pragmatist's belief that it is entirely feasible to deal with variances in your epistemology, ontology, and axiology is confirmed if the research issue does not clearly suggest that either an interpretivist or positivist philosophy is adopted (Saunders et al., 2003).

The pragmatic approach is mostly used to resolve philosophical disagreements that could otherwise go on forever. Is there one world or several?–destined or unbound?—substance or mystical?These are ideas that may or may not reflect the best interests of the world, and disagreements on these ideas are endless. In these situations, the pragmatic approach is to attempt to comprehend each idea by following its corresponding practical ramifications (James, 2020).

2.2.5 Conclusion

To summarise the four research philosophies that were investigated, Saunders et al. (2003) provides the following figure that summarises the ontology, epistemology, axiology, and data collection techniques that are most often used. The table is as follows:

	Positivism	Realism	Interpretivism	Pragmatism
Ontology: *the researcher's view of the nature of reality or being*	External, objective and independent of social actors	Is objective. Exists independently of human thoughts and beliefs or knowledge of their existence (realist), but is interpreted through social conditioning (critical realist)	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to best enable answering of research question
Epistemology: *the researcher's view regarding what constitutes acceptable knowledge*	Only observable phenomena can provide credible data, facts. Focus on causality and law like generalisations, reducing phenomena to simplest elements	Observable phenomena provide credible data, facts. Insufficient data means inaccuracies in sensations (direct realism). Alternatively, phenomena create sensations which are open to misinterpretation (critical realism). Focus on explaining within a context or contexts	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology: *the researcher's view of the role of values in research*	Research is undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; the researcher is biased by world views, cultural experiences and upbringing. These will impact on the research	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective	Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view
Data collection techniques most often used	Highly structured, large samples, measurement, quantitative, but can use qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs, quantitative and qualitative

Figure 2.3: Comparison of four research philosophies in management research

If the above figure is studied, a separation can be made regarding which research philosophy will be appropriate for the current research study. Positivism immediately stands out because of what its epistemology holds to be true, which is that the only reliable source of information that can be drawn upon is observable phenomena. This suits the current study very well as it will be dealing with a case study to implement a system and the conclusions regarding the success of the development project will be drawn from the success of created artefact or information system. The only other philosophy that has an epistemology aligned to the needs of the research project is realism, as it also views observable phenomena as credible sources of fact, although it opposes a direct reliance on observable phenomena as it believes they can be interpreted incorrectly or with a biased view. Interpretivism and pragmatism regard subjective meaning and social phenomena as the critical source of acceptable knowledge, which does not suit the circumstances of the

research project. Therefore, interpretivism and pragmatism are ruled out as options for the chosen research philosophy for this project.

The remaining two options for viable research philosophies must be compared further to find a suitable methodology for the research project. Within the positivistic approach, the research is taken from a third party point of view to remain objective and reliant on the conclusions drawn from the outcome of the research project, while realism ascertains that the researcher is biased by world views and experiences and that this factors will have an impact on the research. As one of the critical purposes of this research project is to create a replicable methodology for how students can consistently build industry level software solutions, it is of the utmost importance that the researcher remain unbiased and objective. Therefore, according to the comparison of epistemology and axiology between positivism and realism, positivism is chosen as the preferred research philosophy for this project.

The next section encompasses the following stage within the modified research onion (Mardiana, 2020), the research approach. This section will be the entry point into the second layer of the research onion.

2.3   Research Approach

Research approaches make up the second layer of the Research Onion. A research strategy aids in the structure of a study by offering direction in determining the theory that the investigation seeks to advance (Saunders et al., 2009). There are three approaches that are offered by the the modified research, namely deduction, abduction, and induction. These three approaches are each investigated in more depth in the subsections that follow. Once they have been reviewed, a conclusion will be made on which option will be taken forward as the approach for this research project.

2.3.1   Deduction

In the deductive method, a hypothesis is generated alongside an established theory in order to test the theory (Saunders et al., 2009). When assessing qualitative data, the deductive and inductive approaches offer a thorough method. To make sense of the entire collection of data and comprehend what is taking place, this procedure entails fully immersing oneself in the reading and consumption of the material (Azungah, 2018). Deductive qualitative research is distinct from other qualitative methodologies since it utilises conceptual premises generated from the review of literature as its starting point and employs them to the gathering and examination of data(Pearse, 2019).

Despite decades of exponential increases in computing capacity, the foundational ideas of the theories of computation still hold true. Thus, the importance of deductive research

methods as a source of specific program knowledge has been established over time (Eden, 2007). Knuth (1968) provides the following justification for his definition of computer science as a sub field of mathematics:

> "Like mathematics, computer science will be somewhat different from other sciences in that it deals with man-made laws, which can be [deductively] proved, instead of natural laws which are never known with certainty"

If the advice of Knuth (1968) is taken into consideration alongside the fact that the current research field is computer science, the deductive approach could be very promising to achieving successful results in this project. The next subsection will outline abduction and the potential it holds for being the chosen research approach.

2.3.2 Abduction

When abduction was first used in 1597 by Julius Pacius to translate the Aristotelian apagoge, it went largely unrecognised for nearly three centuries. The term was initially used by C. S. Peirce (Smyth, 1999), who stated that it would represent the only fully knowledge-extending method of interpreting that would be categorically different from the two typical forms of logical conclusion, namely deduction and induction. In several artificial intelligence domains, including diagnosis, natural language comprehension, default reasoning, database updates, planning, and high-level vision, this type of abduction has become a common reasoning method.

Determining the most plausible explanation for a given collection of data is a challenge that can be classified as abduction (Josephson et al., 1987). Abduction is applicable to many different types of reasoning exercises (Charniak, 1985). For instance, the final diagnosis in medicine clarifies the patient's symptoms and indicators (Pople, 1973; Reggia et al., 1983). According to natural language comprehension, a sentence's intended meaning reveals why it was said (Hobbs et al., 1993). Acceptance of a hypothesis in the establishment of scientific theory depends on how well it explains the data. In abductive reasoning, assumption A is accepted if it implies some observation 0 and aligns with preexisting beliefs (Lewis and Mack, 1982).

Abduction has become a common reasoning method in various artificial intelligence domains, including diagnosis, natural language comprehension, and planning. In the context of this master's thesis in computer science, abduction offers a systematic approach to evaluating student developers' capabilities and comparing their processes with industry standards, thereby aiding in the creation of an industry-standard ERP system for Task-Flow. Through its emphasis on determining the most plausible explanation for a given collection of data, abduction provides a valuable framework for ensuring the feasibility and success of the research project. As the project progresses, abduction will serve as a guiding principle for identifying and addressing challenges, iteratively improving the system, and

ultimately contributing to the advancement of systems development methodologies within both academic and industrial settings.

2.3.3   Induction

Induction is widely used in the field of computer science (CS). Data structures, philosophy of computing (Lynch, 1996; Hopcroft et al., 2001; Barwise and Etchemendy, 1998), programming languages (Pierce, 2002), program efficiency-time complexity (Cormen et al., 2022), and algorithm correctness (Cormen et al., 2022; Lynch, 1996; Page, 2003; Weiss, 1998) are only a few of the computer science fields that depend on it. Furthermore, induction can be employed as a teaching strategy to improve students' understanding and performance with CS concepts such as algorithm design, recursion, and programming languages (Manber, 1989; Wu et al., 1998). According to Bruce et al. (2003),

> "Programmers with a good understanding of mathematical induction find it much easier to write and, even more importantly, provide convincing arguments for the correctness of recursive algorithms."

However, research has shown that, even after receiving repeated training in several courses within their curriculum, students typically struggle to comprehend and execute proofs via induction (Lowenthal and Eisenberg, 1992; Movshovitz-Hadar, 1993; Baker, 1995; Dubinsky, 1989). Even after receiving repeated teaching in several courses within their curriculum, it has been reported in the literature that students generally struggle to comprehend and execute proofs by induction (Polycarpou et al., 2008).

In conclusion, induction serves as a foundational pillar within the field of computer science, playing a vital role across various domains Its significance extends beyond theoretical frameworks, as it also serves as a pedagogical tool to enhance students' understanding and proficiency in fundamental CS concepts. Despite its ubiquity and importance, empirical evidence suggests persistent challenges among students in grasping and applying inductive reasoning. Addressing these challenges requires a nuanced approach that combines theoretical instruction with practical application, leveraging insights from cognitive science and educational psychology to scaffold students' learning experiences effectively. By acknowledging the complexities inherent in mastering induction, educators and researchers can develop tailored interventions aimed at fostering deeper comprehension and proficiency in this essential aspect of computer science education that could lead to a successful outcome within this research project.

The research approach that is made use of within this research paper is deduction as it holds that with this approach a researcher begins with a hypothesis and then aims to acquire evidence to prove it, support it, or outrightly refute it. This approach is used by researchers when they want to test an existing hypothesis rigorously. Therefore, it is the most suited to what is being tested in this research project and will further be used as

the research approach in this project aiming to make use of the assumption that students can build an ERP system of industry standards and put it to the test. The following section regards the next layer of the modified research onion that will be focused on and is called the research strategy, where the methods of data acquisition are investigated and the chosen method is then selected.

2.4   Research Strategy

This layer of the modified research onion refers to the research strategy that will be employed throughout this research project. The research strategies available in the modified research onion are narrative inquiry, grounded theory, action research, design science research, action design research, ethnography, case study, archival research, experiments, and surveys (Mardiana, 2020). As the deductive research approach was selected for this research project, only the strategies that make use of a deductive reasoning approach will be investigated. These research strategies include experiments, surveys, action research, design science, and action design science. They will each be examined in more depth in the subsections that follow.

2.4.1   Design Science

The Design Science Research Methodology, or DSRM, was developed by Peffers et al. (2007) with three goals in keeping in mind: "(1) offer a nominal procedure for carrying out DS study, (2) expand on earlier research on DS in IS and related fields, and (3) offer scholars a conceptual model for a framework for the results of research." The Design Science Research (DSR) paradigm is based on the artificial sciences and engineering. In essence, it is a paradigm for solving problems. DSR creates new artefacts in an attempt to advance human understanding (Hevner et al., 2010). In the past few years, a number of researchers have successfully brought design research into the realm of information science (IS) studies, such as Hevner et al. (2004) and Walls et al. (1992). They are also effective in making design a major part of research and proving the value and legitimacy of design science (DS) as an IS research paradigm. In the fifteen years or more that have elapsed since those first articles, very little DS research has been successfully published in the IS field, despite these effective breaches (Peffers et al., 2007) outlines a process that encompasses six activities that make up the DSR methodology and are arranged in a certain sequence that dictates the order of progression for research based on this methodology. This specific research methodology is investigated in great depth as it forms the basis of action design research that is discussed in a later subsection. The table below outlines these activities:
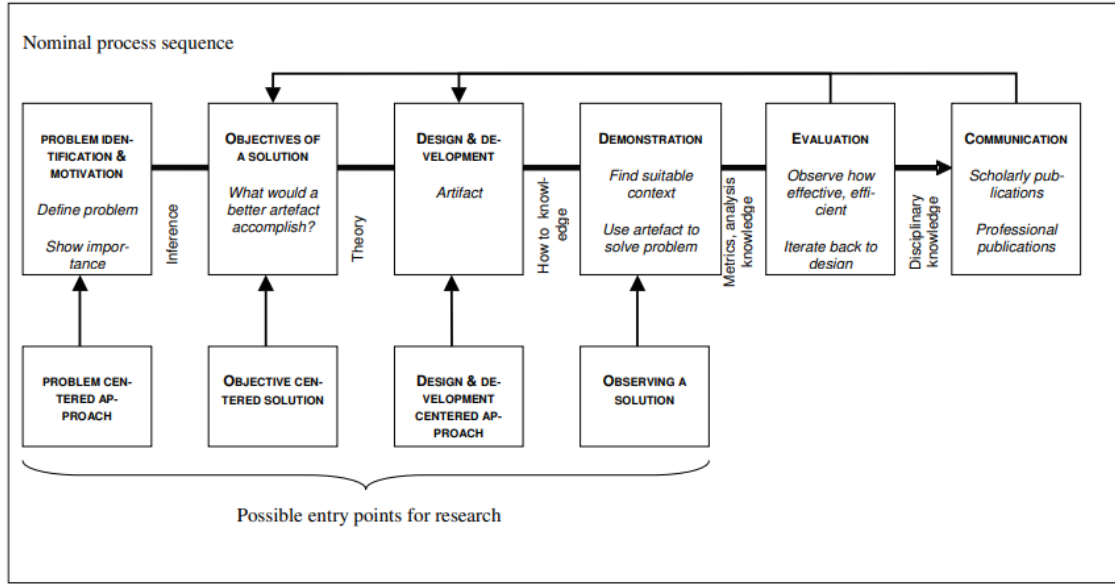
Figure 2.4: Design science research process (DSRP) model

Each step of the DSR research process that is outlined by Peffers et al. (2007) is investigated in broader context to better understand accurate execution and use of the research methodology.

1. Problem Identification and Motivation

   Before coming up with viable solutions, designers work with vague problems that need more investigation (Buchanan 1992; Rittel and Webber 1973). Prescriptive engineering design procedures frequently place a strong emphasis on characterising an issue as the first step. Problem is the driving force behind these problem-first approaches, which use design to find a solution (Dewey, 2022). There for it is of the utmost importance to correctly identify and define the problems and motivation within this research study.

   The purpose of this first activity within the research methodology is of utmost importance as it designates the entry point to the entirety of what will be done within this research. Peffers et al. (2007) specifies what has to be done to properly identify the problem and motivation related to the study. The research problem has to be specified and an explanation to why a solution is valuable must be provided. It could be helpful to conceptually atomize the problem so that the solution can adequately represent the complexity of the problem, as the problem definition will be utilised to create an effective artifactual solution. Two goals are achieved when a solution is justified: first, it encourages the researcher and the research's audience to pursue the answer and accept the findings; second, it clarifies the logic behind the researcher's comprehension of the issue. Knowledge of the problem's current condition and the significance of its solution are among the resources needed for this task.

2. Objectives of the solution

Determine a solution's goals based on the definition of the problem. The goals can be qualitative, such as when a new artefact is anticipated to enable answers to issues not previously addressed, or quantitative, such as terms in which a desirable solution would be preferable to current ones. The goals ought to be as follows: logically inferred from the problem description. Information about the current state of issues, existing solutions, and their efficacy, if any, are among the resources needed for this.

3. Design and Development

This initial phase involves conceptualizing and creating the artifact or solution to address the identified problem or opportunity. According to Hevner et al. (2004), design science research emphasises the creation of novel artifacts, which could be systems, models, methods, or processes, to solve real-world problems. During this phase, researchers draw upon existing knowledge, theories, and best practices designing and develop the artifact, ensuring that it aligns with the objectives and requirements outlined in the problem statement.

4. Demonstration

Once the artifact is developed, it needs to be demonstrated to showcase its functionality and effectiveness. In the demonstration phase, researchers present the artifact in action, highlighting its features and capabilities. Peffers et al. (2007) emphasise the importance of demonstrating how the artifact addresses the identified problem or improves upon existing solutions. This phase allows stakeholders to visualize the artifact's potential impact and provides an opportunity for feedback and refinement before proceeding to the evaluation stage.

5. Evaluation

Evaluation is a critical step in the design science research process, aimed at assessing the artifact's effectiveness, efficiency, and utility. According to Hevner et al. (2004), evaluation involves rigorously testing the artifact against predefined criteria to determine its success in addressing the problem or achieving the desired outcomes. Evaluation methods can vary depending on the nature of the artifact and the research context, but commonly include usability testing, performance measurement, and user feedback. The findings from the evaluation phase inform any necessary refinements or adjustments to the artifact before its implementation.

6. Communication

The final phase of the design science research process involves disseminating the findings and outcomes to relevant stakeholders. Communication plays a crucial role in sharing the knowledge generated through the research and facilitating its uptake and application in practice. March and Smith (1995) emphasise the importance of clear and effective communication strategies to convey the significance of the artifact, its design rationale, and its potential implications for practice or theory. Researchers may use various channels such as academic publications, conferences,

presentations, and technical reports to communicate their findings to both academic and practitioner audiences.

2.4.2 Action Research

2.4.3 Action Design Research

Action research integrates theory with practice, involving both researchers and practitioners, to address immediate issues within an agreed ethical framework. It's an iterative process where researchers and practitioners collaborate on activities like problem identification, taking action, and reflective learning within specific cycles (Avison et al., 1999).

Design research (DR) places artifacts of information technology at the center of the field of information systems. Nevertheless, prevalent DR thinking regards the IT artifact from a technology standpoint and pays little heed to how the organizational context has shaped it. Therefore, the current approaches of design research concentrate on creating the item and leave evaluation for a later, distinct stage. They disregard the fact that the artifact evolves from contact with the organizational context even when its initial design is informed by the researchers' goal, placing a higher priority on technological rigor than organizational relevance (Sein et al., 2011).

Sein et al. (2011) proposes action design research (ADR) as a new DR method to navigate this issue. In order to address pressing organizational issues, AR integrates theory development with researcher intervention (Babüroglu and Ravn, 1992; Baskerville and Wood-Harper, 1998). AR therefore seeks to connect theory with application and action to thought (Susman, 1983). According to Davison et al. (2004), Susman and Evered (2023), it is usually an iterative process built on working hypotheses that are improved across several cycles of investigation. Many researches have stressed that the ADR and DS is similar, and many argue that they are not, others propose a middle ground where methodological support is given by either integrating the two (Sein et al., 2011) or including AR concepts in DR (Pries-Heje et al., 2007).

The goal of the ADR research approach is to create and evaluate a variety of IT artifacts in an organizational setting in order to produce practical design knowledge (Sein et al., 2011). This method addresses two main issues: creating and assessing IT artifacts that target a larger class of problems that are comparable to those seen, and first, intervening and evaluating in specific problem situations that are faced within an organisation. Because of this dual focus, a technique that prioritises the development, application, and assessment of artifacts that represent theoretical underpinnings and research intents is required (Sein et al., 2011).

Sein et al. (2011) presents a figure that outlines the four stages of the ADR method. Each will be described in more depth below the figure. The figure showing the stages is as follows:
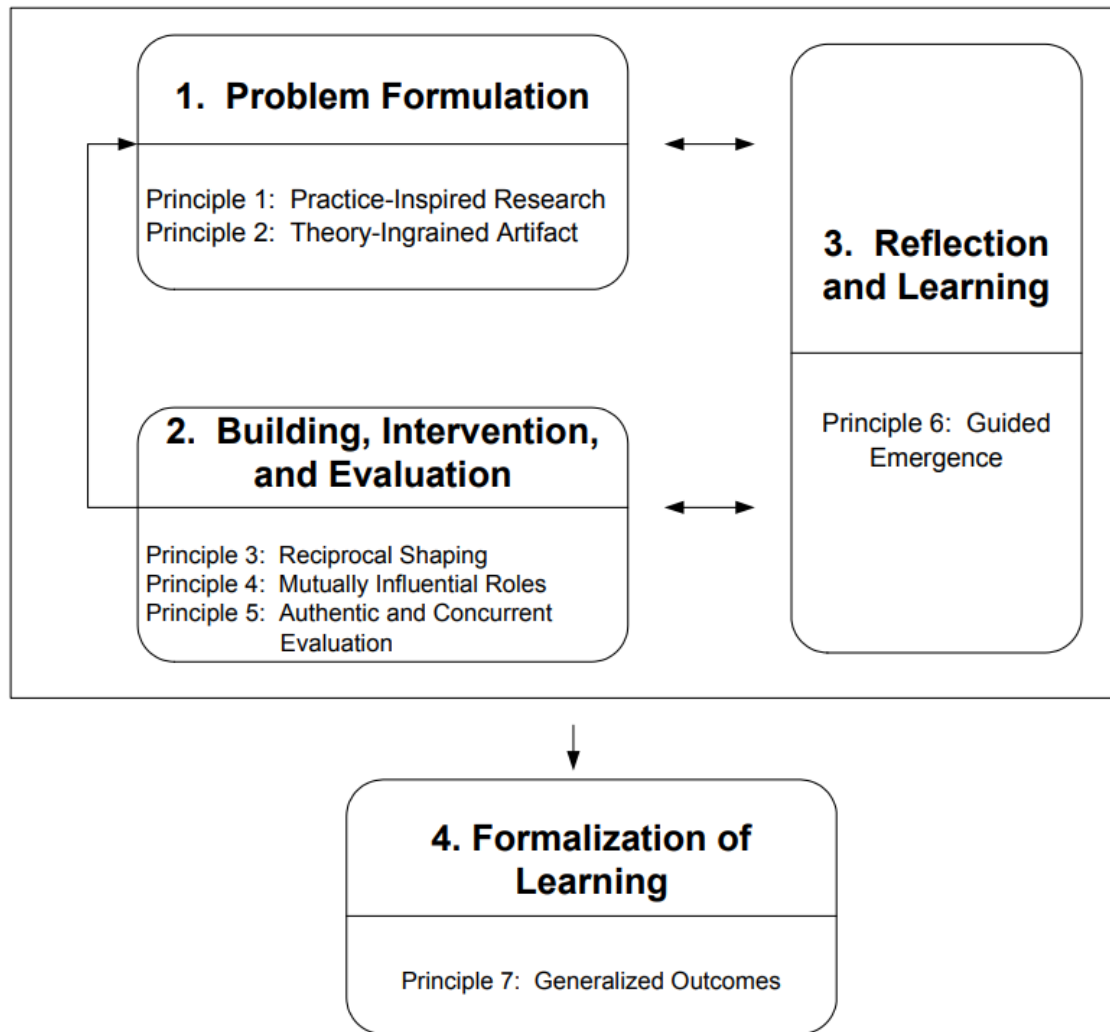
Figure 2.5: The ADR Method: Stages and Principles

Sein et al. (2011) outlines the various tasks that fall within each stage of the process as well. Therefore, the stages and their tasks are discussed and examined below:

1. Problem formulation

   The problem formulation step uses current ideas and tools to identify and conceive a research opportunity (Hevner et al., 2004). A crucial component is characterizing the issue as an example of a certain class of issues. While this definition might be a work in progress, it establishes a foundation for tackling the conflict between addressing the problem at hand and addressing a wider range of issues (Sein et al., 2011). This stage draws on two principles: practice-inspired research and theory-ingrained artifact. Practice-Inspired Research in ADR emphasises leveraging real-world organizational problems as opportunities for knowledge creation, aiming to generate insights applicable to broader problem classes. Theory-Ingrained Artifact underscores the integration of theoretical frameworks into the development and evaluation of artifacts, ensuring they are grounded in established principles for broader applicability beyond the immediate context. The tasks to be completed in

this stage of the research strategy are as follows (Sein et al., 2011):

- Identify and conceptualize the research opportunity
- Formulate initial research question
- Cast the problem as an instance of a class of problems
- Identify contributing theoretical bases and prior technology advances
- Secure long-term organisation commitment
- Set up roles and responsibilities

2. Building, Intervention, and Evaluation

The problem formulation and theoretical foundations chosen in the first stage of ADR are applied in the second stage. These presumptions offer a foundation for creating the IT artifact's initial design, which is then influenced by corporate use and later design cycles. This phase, which is implemented as an iterative process in a target context, integrates the creation of the IT artifact, organizational intervention, and evaluation (Sein et al., 2011). This stage comprises three principles, namely: Principle 3, Reciprocal Shaping, underscores the intertwined influence of IT artifacts and organizational contexts in ADR, involving iterative decision-making cycles within each domain. Principle 4, Mutually Influential Roles, stresses mutual learning between action design researchers and practitioners, where theoretical knowledge and practical insights contribute to a collaborative understanding of organizational challenges. Principle 5, Authentic and Concurrent Evaluation, emphasizes integrating evaluation throughout the research process in ADR, ensuring ongoing refinement and alignment of artifact design and organizational intervention with research objectives. The following are the tasks that are to be completed within the stage of the research strategy:

- Discover initial knowledge-creation target
- Select or customize BIE form
- Execute BIE cycle(s)
- Asses need for additional cycles, repeat

3. Reflection and learning

The process of reflection and learning conceptually shifts from creating a solution for a specific problem to using that knowledge to address a larger class of issues. This stage is ongoing and runs concurrently to the initial two phases. The stage acknowledges that conducting research entails more than just problem-solving (Sein et al., 2011). To make sure that contributions to knowledge are recognized, careful consideration of the problem framing, the selected theories, and the developing ensemble is essential. It is imperative to modify the research methodology in light of preliminary evaluation findings to align with the evolving comprehension of the ensemble artifact (Sein et al., 2011). This stage also comprises a principle. Principle 6, Guided Emergence, blends intentional design with organic evolution in ADR.

It stresses that the final outcome is shaped by both initial design and ongoing refinement influenced by organizational use, participant perspectives, and evaluation outcomes (Sein et al., 2011). The tasks to be completed in this stage are as follows:

- Reflect on the design and redesign during the project

- Evaluate adherence to principles

- Analyze intervention results according to stated goals

4. Formalization of Learning

Formalizing the learning is the aim of the fourth phase of ADR. In accordance with Aken (2004), the situational learning gained from an ADR project must to be expanded upon to create broad concepts for a class of field problem solutions (see Principle 1). This conceptual shift is made easier by grouping the problem-instance into a class of problems (see Stage 1). To formalize the learning, researchers define the organizational results and highlight the accomplishments realized in the IT artifact. These results can be described as design principles and, after more consideration, as improvements to the theories that were part of the original design (Sein et al., 2011). This stage also comprises one principle. Principle 7, Generalized Outcomes, deals with making ADR results applicable beyond specific cases. It involves moving from unique instances to broader solutions, including generalizing problems and solutions, and deriving design principles (Sein et al., 2011). The tasks to be completed in this stage are as follows:

- Abstract the learning into concepts for class of field problems

- Share outcomes and assessment with practioners

- Articulate outcomes as design principles

- Articulate learning in light of theories selected

- Formalize results for dissemination

2.4.4 Experiment

2.4.5 Survey

2.4.6 Conclusion

2.5 Research Design

A researcher's detailed approach for addressing his or her research question(s) is known as the research design (Mardiana, 2020).

2.5.1 Data Collection

2.5.2 Ethical Considerations

2.6 Conclusion

Chapter 3

Literature Study

3.1 ERP Systems

The ERP archive discovered in the distant past may date back to 1970, when business process integration was the primary goal. The ERP was first used by the Gartner Group, and it went into use at the beginning of 1990. The early 1990s saw the introduction of ERP by software companies like SAP. In 1992, SAP released the R/3 version once more. Customer-server hardware structure was added to the SAP R/3 so that it could operate on many stages at once. By 2000, all of the main ERP software system providers had solved the Y2K challenge. By connecting business and management activities, enterprise resource planning (ERP) tools assist organisations in realising their full potential (Uçaktürk and Villard, 2013).

3.1.1   Features of ERP Systems

3.1.2   Competition within the ERP System Industry

3.1.3   Industry Requirements for an ERP System

3.2   The Information Technology Industry

3.2.1   Threats and Opportunities

The Purpose of a University

3.2.2   Developing Nations vs. The Rest of the World

3.3   The Value Chain

3.3.1   People

3.3.2   Processes

3.3.3   Technology

Hardware

Software

Infrastructure

3.3.4   The Economic Viability of Academic and Industry Partnership

3.3.5   Industry Offering Resources to Universities

3.4   Commercialization of Software

3.4.1   Methods of Commercialization

Recommendation

3.5   Students in Industry

3.5.1   Advantages

Chapter 4

Case Study

4.1 University

4.1.1 Academic Deliverables

4.2 Industry

4.3 Implementation of Project Management Methodology

4.4 Student Team and Roles

4.5 Project Design

4.5.1 Requirements Gathering

Internal Questioning

Abstract Requirements Summary

Functional Requirements Summary

Feature Comparison

4.5.2 System Requirements Definition

Year 1 Prototype

Year 2 Client Configuration

Chapter 5

Expert Reviewer

Chapter 6

Results and Discussion

6.1   Recommendations

Chapter 7

Conclusion

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Bibliography

Aken, J. E. v. (2004). Management research based on the paradigm of the design sciences: the quest for field-tested and grounded technological rules. *Journal of management studies*, 41(2):219–246.

Alharahsheh, H. H. and Pius, A. (2020). A review of key paradigms: Positivism vs interpretivism. *Global Academic Journal of Humanities and Social Sciences*, 2(3):39–43.

Amini, M. and Abukari, A. M. (2020). Erp systems architecture for the modern age: A review of the state of the art technologies. *Journal of Applied Intelligent Systems and Information Sciences*, 1(2):70–90.

Archer, M. (2013). *Social origins of educational systems*. Routledge.

Avison, D. E., Lau, F., Myers, M. D., and Nielsen, P. A. (1999). Action research. *Communications of the ACM*, 42(1):94–97.

Azungah, T. (2018). Qualitative research: deductive and inductive approaches to data analysis. *Qualitative research journal*, 18(4):383–400.

Babüroglu, O. N. and Ravn, I. (1992). Normative action research. *Organization Studies*, 13(1):019–34.

Baig, M. Z., Haq, M. U. U., Surkhail, H. M. U., Iqbal, R., and Sheikh, M. M. (2018). Bridging the industry-academia collaboration gap a focus towards final year projects. In *Proceedings of the 2nd International Conference on High Performance Compilation, Computing and Communications*, pages 40–44.

Baker, J. D. (1995). *Characterizing students' difficulty with proof by mathematical induction*. Indiana University.

Barnett, D. R. (2011). Partnering industry and education for curricular enhancement: A response for greater educational achievement. *Online Journal for Workforce Education and Development*, 5(2):5.

Barwise, J. and Etchemendy, J. (1998). *Computers, visualization, and the nature of reasoning*. na.

Baskerville, R. and Wood-Harper, A. T. (1998). Diversity in information systems action research methods. *European Journal of information systems*, 7:90–107.

Bhaskar, R. (2013). *A realist theory of science*. Routledge.

Bruce, K. B., Drysdale, R. L. S., Kelemen, C., and Tucker, A. (2003). Why math? *Communications of the ACM*, 46(9):40–44.

Buchanan, R. (1992). Wicked problems in design thinking. *Design issues*, 8(2):5–21.

Carlsson, S. A. (2003). Critical realism: a way forward in is research. In *ECIS*, pages 348–362.

Charniak, E. (1985). *Introduction to artificial intelligence*. Pearson Education India.

Cormen, T. H., Leiserson, C. E., Rivest, R. L., and Stein, C. (2022). *Introduction to algorithms*. MIT press.

Davison, R., Martinsons, M. G., and Kock, N. (2004). Principles of canonical action research. *Information systems journal*, 14(1):65–86.

Dewey, J. (2022). *How we think*. DigiCat.

Dubinsky, E. (1989). Teaching mathematical induction ii. *Journal of Mathematical Behavior*, 8(3):285–304.

Easton, G. (2010). Critical realism in case study research. *Industrial marketing management*, 39(1):118–128.

Eden, A. H. (2007). Three paradigms of computer science. *Minds and machines*, 17:135–167.

Flick, U., Von Kardorff, E., and Steinke, I. (2004). What is qualitative research? an introduction to the field. *A companion to qualitative research*, 1:3–11.

Foley, J. (1997). Technology transfer from university to industry. In *Proceedings of the 2nd international conference on Intelligent user interfaces*, pages 3–4.

Goldkuhl, G. (2012). Pragmatism vs interpretivism in qualitative information systems research. *European journal of information systems*, 21:135–146.

Hevner, A., Chatterjee, S., Hevner, A., and Chatterjee, S. (2010). Design science research in information systems. *Design research in information systems: theory and practice*, pages 9–22.

Hevner, A. R., March, S. T., Park, J., and Ram, S. (2004). Design science in information systems research. *MIS quarterly*, pages 75–105.

Hobbs, J. R., Stickel, M. E., Appelt, D. E., and Martin, P. (1993). Interpretation as abduction. *Artificial intelligence*, 63(1-2):69–142.

Hopcroft, J. E., Motwani, R., and Ullman, J. D. (2001). Introduction to automata theory, languages, and computation. *Acm Sigact News*, 32(1):60–65.

James, W. (2020). Pragmatism. In *Pragmatism*, pages 53–75. Routledge.

Josephson, J. R., Chandrasekaran, B., Smith, J. W., and Tanner, M. C. (1987). A mechanism for forming composite explanatory hypotheses. *IEEE Transactions on Systems, Man, and Cybernetics*, 17(3):445–454.

Knuth, D. E. (1968). Semantics of context-free languages. *Mathematical systems theory*, 2(2):127–145.

Lewis, C. and Mack, R. (1982). The role of abduction in learning to use a computer system.

Littlejohn, S. W. and Foss, K. A. (2009). *Encyclopedia of communication theory*, volume 1. Sage.

Lowenthal, F. and Eisenberg, T. (1992). Mathematical induction in school: An illusion of rigor? *School Science and mathematics*, 92(5):233–238.

Luczak-Rösch, M. (2013). Beyond positivism in computer science.

Lynch, N. A. (1996). *Distributed algorithms*. Elsevier.

Manber, U. (1989). *Introduction to algorithms: a creative approach*. Addison-Wesley Longman Publishing Co., Inc.

March, S. T. and Smith, G. F. (1995). Design and natural science research on information technology. *Decision support systems*, 15(4):251–266.

Mardiana, S. (2020). Modifying research onion for information systems research. *Solid State Technology*, 63(4):5304–5313.

Movshovitz-Hadar, N. (1993). Mathematical induction: A focus on the conceptual framework. *School Science and Mathematics*, 93:408–408.

Page, R. L. (2003). Software is discrete mathematics. *ACM SIGPLAN Notices*, 38(9):79–86.

Park, Y. S., Konge, L., and Artino Jr, A. R. (2020). The positivism paradigm of research. *Academic medicine*, 95(5):690–694.

Pearse, N. (2019). An illustration of deductive analysis in qualitative research. In *18th European conference on research methodology for business and management studies*, page 264.

Peffers, K., Tuunanen, T., Rothenberger, M. A., and Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of management information systems*, 24(3):45–77.

Pierce, B. C. (2002). *Types and programming languages*. MIT press.

Polycarpou, I., Pasztor, A., and Adjouadi, M. (2008). A conceptual approach to teaching induction for computer science. In *Proceedings of the 39th SIGCSE technical symposium on Computer science education*, pages 9–13.

Pople, H. E. (1973). On the mechanization of abductive logic. In *IJCAI*, volume 73, pages 147–152. Citeseer.

Potrac, P., Jones, R. L., and Nelson, L. (2014). Interpretivism. In *Research methods in sports coaching*, pages 31–41. Routledge.

Pries-Heje, J., Baskerville, R., and Venable, J. (2007). Soft design science research: Extending the boundaries of evaluation in design science research. In *Proceedings from the 2nd International Conference on Design Science Research in IT (DESRIST)*, pages 18–38.

Reggia, J. A., Nau, D. S., and Wang, P. Y. (1983). Diagnostic expert systems based on a set covering model. *International journal of man-machine studies*, 19(5):437–460.

Rittel, H. W. and Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy sciences*, 4(2):155–169.

Ryan, G. (2018). Introduction to positivism, interpretivism and critical theory. *Nurse researcher*, 25(4):41–49.

Saunders, M., Lewis, P., and Thornhill, A. (2003). Research methods forbusiness students. *Essex: Prentice Hall: Financial Times*.

Saunders, M., Lewis, P., and Thornhill, A. (2009). *Research methods for business students*. Pearson education.

Sayer, R. A. (1992). *Method in social science: A realist approach*. Psychology Press.

Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., and Lindgren, R. (2011). Action design research. *MIS quarterly*, pages 37–56.

Smyth, R. (1999). Peirce, pragmatism and the logic of scripture.

Susman, G. I. (1983). Action research: a sociotechnical systems perspective. *Beyond method: Strategies for social research*, 95(113):95.

Susman, G. I. and Evered, R. D. (2023). An assessment of the scientific merits of action research. *STUDI ORGANIZZATIVI*, (2022/2).

Uçaktürk, A. and Villard, M. (2013). The effects of management information and erp systems on strategic knowledge management and decision-making. *Procedia-Social and Behavioral Sciences*, 99:1035–1043.

Walls, J. G., Widmeyer, G. R., and El Sawy, O. A. (1992). Building an information system design theory for vigilant eis. *Information systems research*, 3(1):36–59.

Weiss, M. A. (1998). Data structures and problem solving using java. *ACM SIGACT News*, 29(2):42–49.

Wikgren, M. (2005). Critical realism as a philosophy and social theory in information science? *Journal of documentation*, 61(1):11–22.

Wu, C.-C., Dale, N. B., and Bethel, L. J. (1998). Conceptual models and cognitive learning styles in teaching recursion. In *Proceedings of the twenty-ninth SIGCSE technical symposium on Computer science education*, pages 292–296.