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A SYSTEMIC EXPLORATION OF RISKS IN MOBILE APPLICATION DEVELOPMENT PROJECTS AND ENVIRONMENTS

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ABSTRACT

Purpose - The aim of this research is to develop an understanding of the most common risks encountered during mobile application development projects and identify the interrelationships that exist between these risks to highlight the core risk drivers that negatively impact these projects and outcomes.

Research design and methodology - This study adopted a holistic approach using Warfield's Interactive Management (IM) methodology to understand the risks that hinder MAD projects and understand the interrelationships between these risks to identify the core driving risks. IM can be divided into four phases. In the first phase, Idea generation, participants were asked through a survey to define their role and list the risks they perceive as most important within their environment. The second phase, Idea clarification, was actioned through online video calls where participants discussed the risks to get a shared understanding of each risk. The third phase, Idea structuring, was also executed through online video calls where participants agreed on the relationships that exist between each risk through pair-to-pair comparison using Interpretive Structural Modelling (ISM) software. The final phase, Interpretation, required participants to review the interpretive structural model and agree on the core risks that mainly negatively impact MAD projects.

Research finding - The research revealed three core risks that significantly lead to other risks that will negatively impact MAD projects and environments within the context of this study. These risks include 'Lack of platform knowledge', 'Poor team skills and capabilities', and 'Poor quality and observability of data/analytics to understand user behaviour'.

Value of the research – This research contributes to the following: 1) Risks that are identified and prioritised as dominant risks can be compared to the lists from existing studies that aimed to highlight unique risks in MAD projects, 2) By understanding the inter-relationships between risks, a few root causes/risk drivers can be highlighted which should receive more attention throughout the project, 3) By adopting a systemic approach, it helps to reveal context-specific issues which may not be available in existing literature, and 4) The collaborative learning nature of the IM approach adds to research on the sustainability of complex MAD projects implemented in pluralist and coercive environments.

Keywords - Mobile application development, Risk management, Systemic thinking, Interactive Management, Interpretive Structural modelling

Table of Contents

List of tables

List of Figures

List of Addenda

CHAPTER 1: Introduction and background to the study

1.1 . Introduction

The first chapter provides a theoretical background to the study by briefly discussing characteristics and challenges that make mobile application development projects unique to traditional software development projects and environments. This is followed by the problem statement, research question, research objectives, and the structure for the remainder of the document.

Since Apple introduced their App store in 2008 the mobile application market has experienced exponential growth (Dehlinger & Dixon, 2011, Flora & Chande, 2013, 2014a, Flora *et al.*, 2014b, Wasserman, 2010, Williamson, 2012) and smart mobile devices are the fastest expanding computing platform (Dehlinger & Dixon, 2011). Recent statistics indicate that smartphone users surpass six billion globally, and is forecasted to further expand by several hundred million in the next few years (O'Dea, 2021). This resulted in numerous device makers racing to secure a share of this fast-growing market (Williamson, 2012). Unfortunately, mobile application development (MAD) projects still experience high failure rates with 80-90% of applications uploaded to mobile application stores being abandoned after a single use (Goyal, 2019). Furthermore, over 50% of Android applications on the Google Play store receive few to no downloads, and over 60% of those that receive reasonable downloads experience an 80% drop-off rate within the first week, never to be used again (Petrov, 2016). MAD projects and environments are still believed to be complex by nature and approaches used in traditional software development environments are not necessarily appropriate for MAD projects and environments (Flora & Chande, 2013, 2014a, Flora *et al.*, 2014b, Wasserman, 2010). Although characteristics such as lifecycle models, cross-team cooperation, traceability within the project, and code version control can be shared amongst traditional software and MAD projects (Williamson, 2012) mobile applications have distinctive features that are specifically associated with MAD projects.

One of the most widely recognized features that makes mobile applications unique is the integration between hardware (the physical mobile device) and the software installed on the mobile device (Flora *et al.*, 2014a, Kakkar *et al.*, 2013, Vithani & Kumar, 2014, Wasserman, 2010, Williamson, 2012). One example would be when the application needs to make use of the mobile device camera to take photos or scan barcodes. This would require the mobile application to seamlessly integrate with the device’s camera capabilities. Another example would be if a mobile application provides voice recording functionality. In this scenario, the application needs to be able to use the device’s microphone for recording purposes. It is therefore crucial for the mobile application to interact with the different features of the physical mobile device. Given that there are a wide variety of devices in the market, it becomes clear why this characteristic of MAD projects needs to be understood and managed effectively.

Another feature that is widely cited that makes MAD projects and environments unique is the size of the mobile screens and how it impacts the front-end designs and user experience (Dehlinger & Dixon, 2011, Kakkar *et al.*, 2013, Păvăloaia, 2013, Vithani & Kumar, 2014, Williamson, 2012). Screen sizes on mobile devices are significantly smaller when compared to laptops or desktop devices. The information displayed and user input actions, therefore, have limited space and require unique user-interaction flows. Furthermore, this will impact the design of the application, which in turn, will impact the actual development of the application (Wasserman, 2010). In addition to the limited screen sizes, there are also a variety of screen sizes and there is no universal user interface across different mobile devices within the market (Dehlinger & Dixon, 2011). Since the screen sizes are much and vary between device providers, this is a unique feature that is important to consider within MAD projects and environments.

A third unique feature highlighted by a variety of authors is the different platform and hardware providers as well as the development language chosen when building a mobile application, i.e. native, web, or hybrid (Dehlinger & Dixon, 2011, Flora *et al.*, 2014a, Hu *et al.*, 2019, Wasserman, 2010, Williamson, 2012). Apple, with its iOS operating system (Apple, 2021), and Android, which is mainly supported by Google Mobile services GMS) (Hildenbrand, 2019), are two of the largest service providers within the mobile phone market (Kuroda *et al.*, 2019). However, they are not the only service providers that offered bespoke solutions. In 2010 Microsoft launched their platform that caters for Windows mobile devices and launched the Windows Phone store that included 130 000 applications in 2013 and later grew to 300 000 application in 2014 (Murphy, 2014). However, Microsoft later experience a decline in market share and in 2017 the company publicised that they no longer focused on expanding and maintaining their platform, and going forward, they would only service Windows phones with bug fixes and security updates (Bowden, 2020). In 2016 Blackberry's also experienced a rapid decline in their market, forcing them to stop manufacturing their own devices (Appolonia, 2019). The company mainly outsourced this service to TCL communications who recently announced that they will no longer manufacture Blackberry devices since they no longer have the majority of the rights to design and manufacture these devices. Without the supply of Blackberry devices from TCL, the organisation will likely lose a significant amount of global coverage (Kastrenakes, 2020). In 2020 Huawei was forced to make way for its ecosystem amid America's restrictions imposed on Google's trade with Huawei, prohibiting the company from using Google's Mobile Services for applications that operate on Huawei devices (Mzekandaba, 2020). Huawei recently introduced their operating system, Huawei Mobile Services (HMS), that was launched in their new high-end mobile devices (Huawei, 2020, Kahla, 2020, Mzekandaba, 2020). However, older Huawei devices still rely on GMS operating platform (Mishra, 2020).The company has committed to partner with local developers and organisations to offer popular applications on their own mobile application store, Huawei AppGallery (Kahla, 2020), and as a result, experienced great market uptake locally (Mzekandaba, 2020). The market changes over the past decade suggest that although there are large competitor's dominating the market, there is still opportunities for new service providers to enter the market with bespoke operating systems, development languages, and platforms.

Security was highlighted as a fourth feature that makes MAD projects and environments unique. Insecure mobile applications can cause serious data privacy issues and can have severe consequences for users and organizations alike (Jain & Shanbhag, 2012). Most research exploring security in MAD projects and environments focus mainly on Android operating systems due to its open-source approach, which increases security concerns (Mylonas *et al.*, 2013, Shabtai *et al.*, 2010, Theoharidou *et al.*, 2012).

A fifth feature explored in the literature on MAD projects is non-functional requirements. While functional requirements describe the behaviour of the system, non-functional requirements relate to capabilities and limitations that affect the system's functionality/behaviour (Dias Canedo & Cordeiro Mendes, 2020). While most non-functional requirements have been considered in light of traditional software development (Dias Canedo & Cordeiro Mendes, 2020, Kurtanovic & Maalej, 2017, Wasserman, 2010), some points should receive special attention considering MAD projects (Wasserman, 2010); 1) Network connection - different types of network connections exist, such as telephone connections (3G and 4G) and Wi-Fi connections. Designers and developers need to consider whether the mobile application will behave differently when connected to these networks. 2) Data integrity - will the synchronization techniques from traditional client-server computing be sufficient, or should new techniques be considered, 3) Speed of networks – different connections worldwide vary in speed and need to be considered when designing the applications, 4) Device capabilities need to be considered – the capabilities of the device (such as the battery, camera, location services) that will be used by the application.

Finally, some authors recognize the complexity of quality assurance testing as a sixth unique feature to be considered since there is an abundance of tools available to ensure high-quality applications are delivered (Flora *et al.*, 2014a, Kakkar *et al.*, 2013, Wasserman, 2010). Examples of such tools include, but are not limited to, 1) device emulator software that uses laptop or desktop devices, eliminating the need to test on actual mobile devices; 2) automation testing routinely assess core application functionality and ensure the application still works as expected; and 3) manual testing is used to test certain features of the application against a specific device (Zein *et al.*, 2016). The quality of the final product is determined by the chosen tools and strategies (Zhifang *et al.*, 2010) and is, therefore, an important factor unique to MAD projects.

1.2. Background

Considering the unique characteristics and challenges described above, the following section will assess the different approaches in the literature that are typically used to address risks in IT environments.

Software projects are high-risk activities that generate varying performance outcomes (Charette, 1996). Industry surveys indicate that only about a quarter of software projects succeed, resulting in billions of dollars being lost annually through project failures (Charette, 1996, Charette, 2005). One of the major contributors to project success is controlling the inherent risks associated with these types of projects (Bannerman, 2008). Project risk in project management is defined as the degree of exposure to negative events and their probable consequences (Barki *et al.*, 1993). Furthermore, identifying and addressing risks early in development lowers long-term costs and helps prevent software disasters (Boehm, 1991). Early research shows that one or more of four approaches to risk management are generally found in the literature and practice. These include checklists, analytical frameworks, process models, and risk response strategies (Bannerman, 2008).

The checklist approach is aimed at identifying and listing the most common risks in order of their probability and impact. These lists are usually compiled through industry surveys targeting project managers and developers. From the extensive literature review, Bannerman (2008) provided examples of such checklists which included studies done by Barki *et al.* (1993); Boehm (1991); Johnson *et al.* (2001); Schmidt *et al.* (2001); and Addison & Vallabh (2002). These papers include items such as unrealistic schedules and budgets, unclear requirements, technical complexity, team members, reusable software, tools, and the environment, etc. One of the benefits of this approach is that it provides quick and cost-effective ways for project managers to assess the project's risk exposure. One of the issues with this approach is how project managers would know which list to choose. The chosen list may not effectively include the factors relevant to a specific project (Bannerman, 2008).

Another approach to risk management research is analytical frameworks where risks are placed in high-level categories according to related themes (Bannerman, 2008). A variety of risk categories and themes have been proposed. One popular theme is categorising risks based on their perceived source, such as client, self, task, environment. etc (Barki *et al.*, 1993, Boehm, 1991, Jiang & Klein, 2000, Wallace *et al.*, 2004). Another example of the analytical framework approach is the lifecycle-based risk management approach and was suggested by authors such as (Lam, 2004, Roy *et al.*, 2016, Sahu *et al.*, 2014). The idea of this approach is for project managers to identify and assess risks within major phases of a project. Similar to the first approach, the analytical framework approach cannot necessarily be adopted for all projects as it will not always be representative of the specific project and its environment (Bannerman, 2008).

A third approach typically found in research and practice are process models that specify activities necessary to manage risk in software projects, for example, risk identification, analysis, response and control. Prominent examples of a process approach include the Project Management Institute's (PMI, 2017) PMBOK guide as well as various industry and national standards such as PRINCE2 (APMG Group, 2003), and ISO and IEEE standards (ISO, 2017). Academic literature was presented by Charette (1996) and Pinto & Morris (2004) who suggested activities such as identification, analysis, planning, resourcing, controlling, and monitoring. The first three risk management approaches described are interrelated and can be used together. For example, checklists and the categories (from analytical frameworks) can be used within certain steps of a process such as identification and analysis (Bannerman, 2008).

A fourth risk management approach typically found in literature focuses on risk response strategies that suggest high-level response options based on the circumstances of the project, threats, response cost, and the required resources. The main idea behind these strategies is to either reduce the likelihood of risk, or limit its impact, or both(Bannerman, 2008). Four common response strategies were found in literature: 1) Avoidance - prevent a negative effect occurring or impacting a project; 2) Transference - shifting the responsibility for risk to a third party, 3) Mitigation - reducing the likelihood and/or potential impact before the risk is realized; and 4) Acceptance – choosing to accept the risk (Boehm & Turner, 2003, DeMarco & Lister, 2003, Kerzner, 2017). Although this approach is effective in providing general options for consideration when formulating response strategies, they do not provide generic strategies for unforeseen risks (Bannerman, 2008). To accommodate for these unforeseen risks Schroeder & Hatton (2012) provided some suggestions to incorporate resilience within risk response strategies through 1) comprehensive capacity development approach, 2) shared financial information with all project partners, 3) purposefully built relationships and trust between project partners, and 4) the use of Web 2.0 technologies to encourage project partner collaboration and effective responses to unforeseen threats. The idea is to consider these suggestions collectively (rather than in silos) in promoting project resilience and manage unforeseen risk.

Existing studies focus largely on a variety of risks in isolation, taking on a reductionist approach (Kanjanda & Tuan, 2020). However, numerous authors argue that risk factors are fundamentally dependent and interact dynamically and in a nonlinear manner (Ambrósio *et al.*, 2011, Büyüközkan & Ruan, 2010, Lopes *et al.*, 2015, Yang *et al.*, 2014), highlighting the importance of understanding the relationships that exist between risk factors. In an early publication that reviewed existing literature, White (1995) stated that the mechanistic and reductionist approach to problem-solving underpins most risk assessment methods. It was found that these reductionist approaches fail to consider situations where one risk aggravates or magnifies another risk. It was also argued that reductionist approaches fail to account for situations where the impact of a portfolio of risks is more significant than the sum total of the individual risks, a phenomenon referred to as emergence (Ackermann *et al.*, 2014). The following section will discuss the complexities inherent within these projects to discover approaches that are well-suited to address this complexity and the underlying risks.

1.3 Problem statement

Industry statistics indicate that MAD projects still experience high failure rates and most applications that do make it to the online application stores are eventually abandoned after a single-use. Furthermore, the complexity of MAD projects is multi-faceted and MAD project environments have contextual and unique project risks inherent in their environments that make them more complex. Although some research was done to identify and list important risks that exist in MAD environments and projects, little attention has been given to understanding the interrelationships that exist between these risks and what the main risk drivers are that lead to project failure.

1.4 Research questions

To address the research problem stated above, the research questions for this study are as follows:

1. What are the risks commonly encountered specifically in MAD projects?
2. What are the interrelationships between these risk factors?
3. What are the root causes or key risk drivers unique to MAD projects?

1.5 Aim of this study

The aim of this research is to develop an understanding of the most common risks encountered during MAD projects and identify the interrelationships that exist between these risks to highlight the core risk drivers.

1.6 Research objectives

To address the research problem stated above, the questions for this research are as follows:

4. Identify unique risks in MAD projects that typically affect project success.
5. Understand the relationships that exist between these risk factors.
6. Describe the root causes or risk drivers unique to MAD projects.

1.7 Structure of Dissertation

1.7.1 Chapter 1: Introduction and background to the study

Introduce the research topic by providing the rationale behind the study as well as an outline of the research approach and structure of the dissertation. Furthermore, this chapter will provide comprehensive information on the study background, including a description of the unique characteristics of MAD projects and the associated challenges.

1.7.2 Chapter 2: Literature review

Critical literature review of risk identification studies within traditional software development environments, followed by a detailed review of risks identified through studies that mainly focussed on MAD projects and environments.

1.7.3 Chapter 3: Research methodology

The complexities in MAD environments will be addressed and rationalise why soft systems approaches are more suitable for dealing with MAD complexities. A detailed description of the Interactive Management methodology will be provided and how it can be used to study MAD projects.

1.7.4 Chapter 4: Research findings and discussion

This chapter will present a detailed analysis of findings from the Interactive Management intervention.

1.7.5 Chapter 5: Conclusion

This chapter will summarise everything covered in the previous chapters of the study with an emphasis on critical reflection from the findings. Limitations, recommendations and areas for future research, and the contribution to knowledge will also be addressed in this chapter.

CHAPTER 2: The Literature review

2.1 Risk and its management

Risk is defined as an uncertain event that if it occurs has a negative or positive impact on the objectives of projects (Barki *et al.*, 1993, Edwards *et al.*, 2020, PMI, 2017). Therefore, risks can travel in two directions: 1) where the outcomes are better than expected, or 2) the outcomes are worse than expected. However, most people associate the concept of risk with negative effects (threats) (Loosemore *et al.*, 2006) and the positive impact of risk (opportunities) is generally neglected in project risk management (Edwards *et al.*, 2020). Opportunity risks involve exploiting enhancements in practice that makes decision-making easier and defend whatever the subsequent outcome (Chapman & Ward, 2011). However, it is important to note that by exploiting opportunities project managers and organisations will almost certainly introduce more threats that need to be identified, analysed and monitored (Edwards *et al.*, 2020). For example, an IT project initiated to provide existing customers with options to personalise their online orders may create the opportunity to also extend these services to new markets and increase the customer base. However, this opportunity is a potential threat if the production processes are unable to effectively meet the increased demand (Edwards *et al.*, 2020).

Aligning with the more popular stance, this study will view risks as threats that will negatively impact project objectives if not identified, analysed and monitored effectively (Edwards *et al.*, 2020, Loosemore *et al.*, 2006).

Risk Management is a term introduced to describe measures and activities implemented to manage these negative risks (Addison & Vallabh, 2002) and it mainly focuses on finding answers to three questions (Kanjanda & Tuan, 2020):

1. What risks are we are exposed to in a particular environment?
2. Of these risks, which ones are the right risks to manage? and
3. What measures can we take to proactively manage the right risks?

Three phases are defined in project management literature that seeks to answer these three questions: 1) risk identification; 2) risk analysis; 3) risk response (Kanjanda & Tuan, 2020, Loosemore *et al.*, 2006). Therefore, project risk management can be defined as a systematic process used to identify, assess, and respond to risks within organisational or project environments (Loosemore *et al.*, 2006).

Furthermore, project risk management requires proactively working with a variety of stakeholders to minimize the probability of risks associated with project decisions (Didraga, 2013, Loosemore *et al.*, 2006). It is also important to understand that each of these project stakeholders perceives risks differently (Addison & Vallabh, 2002, Boehm, 1988, de Camprieu *et al.*, 2007, Mursu *et al.*, 2003, Schmidt *et al.*, 2001). Risk is socially grounded and stakeholders mainly derive their understanding of risks, and attitudes towards them, from the society in which they live and work (Edwards *et al.*, 2020). Therefore, to understand which important risks projects are exposed to, and how they will be managed, the project manager and organisation needs to consider a variety of stakeholder perceptions when making project decisions.

This research is primarily focused on answering questions 1 and 2 of risk management. Participants will be expected to identify risks they encounter in MAD projects. These risks are then assessed to identify the most important risks to manage. Furthermore, to accommodate a variety of risk perspectives participants will be chosen from different backgrounds and roles.

A wide variety of well-cited studies that focussed on risks in IT environments based their conclusions around traditional software development projects and approaches, such as website development or desktop application development. Mobile application development is still considered to be complex, and risk within traditional software development environments may not be directly applicable to a mobile environment (Flora & Chande, 2013, Flora *et al.*, 2014a, Flora *et al.*, 2014b, Kakkar *et al.*, 2013, König-Ries, 2009, Wasserman, 2010). Although there are some shared features and risks between traditional software development and MAD projects; such as lifecycle models, cross-team cooperation, and version controlling (Williamson, 2012), there are also unique and distinctive features associated specifically with MAD projects. To accommodate for risks that are shared between traditional software development projects and MAD projects, this chapter will start by reviewing studies on risks within traditional software development/IT projects. Thereafter, research on risks specifically in MAD projects will be reviewed.

2.2 Risks in traditional software development projects

Software projects are high-risk endeavours that produce varying performance outcomes (Charette, 1996). According to industry surveys, only about one-quarter of software projects are successful, which results in expensive annual losses as a result of project failure (Charette, 1996, Charette, 2005). A key contributor to project success is analysing and managing the underlying risks related to software development projects (Bannerman, 2008). Unidentified and unmanaged risks have been stated by many researchers as a key component that led to IT project failure (Alter & Ginzberg, 1978, Baccarini *et al.*, 2004, Barki *et al.*, 1993, Boehm, 1991, Charette, 2005, Kendrick, 2015).

Through structured interviews with system users and designers, Alter & Ginzberg (1978) studied 56 software systems and identified eight risk factors that affect software development projects. These risk factors are largely related to a process and occur in the early phases of the project. The identified risks are:

1. Designer lacking experience with similar systems;
2. Non-existent or unwilling users;
3. Multiple users or designers;
4. Turnover among users, designers or maintainers;
5. Lack of support for the system;
6. Inability to specify purpose or usage patterns in advance;
7. Inability to predict and cushion the impact on all parties; and
8. Technical problems, Cost-effectiveness issues.

The authors acknowledged that the list is neither comprehensive nor prioritised. Instead, it includes merely generic conditions based on the project and environment being studied that appeared to decrease the probability of successful project implementation in the sampled projects.

Through a survey with experienced project managers, Boehm (1991) defined a checklist with the top 10 important sources of risk in software projects:

1. Personnel shortages
2. Impractical schedules and budgets;
3. Developing incorrect functions;
4. Developing an incorrect user interface;
5. Gold-plating;
6. Continuous and frequent changes in requirements;
7. Shortfalls in externally supplied components;
8. Shortfalls in externally performed tasks;
9. Realtime performance shortfalls; and
10. Lack of computer-science capabilities.

Boehm (1991) indicated that the majority of the top 10 sources were concerned with the team's lack of knowledge of the software development domain and requirement management. Although such checklists can provide a fast and cost effective way to identify and assess the risk exposure of the project, it does not always sufficiently address the unique factors related to a specific project (Bannerman, 2008). The top ten list presented by Boehm did not elaborate on the unique factors to rationalise the ranking of risk factors and was mainly focused on the perceptions of project managers, not the wider stakeholder community.

Through a questionnaire from project leaders and representatives from 75 organisations, that measures the uncertainty and the extent of potential loss related to a software development project, Barki *et al.* (1993) organise the risk factors into five general risk categories:

1. Technological newness;
2. Application size;
3. Lack of expertise;
4. Application complexity; and
5. Organizational environment.

In a study to identify and understand what factors contribute to software project risk and which processes are used to control them, Addison & Vallabh (2002) examined the responses from 36 experienced project managers, specifically from the IT and Finance industries. Although not specified in the study, respondents could have been representative of different cultures since they were approached with an email survey whereby they recommended other project managers from different organisations. The data collection was done online, and therefore not necessarily limited to a specific geographical location and culture. Data was analysed using rank order methods, frequency scales, and regression analysis and 10 risks were identified:

1. Vague or misinterpreted scope/objectives;
2. Misunderstanding the requirements;
3. Lack of user involvement;
4. Absence of senior management commitment;
5. Developing incorrect software functions;
6. Impractical timelines and budgets;
7. Continuous changes to requirement;
8. Lack of knowledge/skills;
9. Inadequate project management methodology; and
10. Gold-plating.

Similar to the studies done by Alter & Ginzberg (1978), Boehm (1991), and Barki *et al.* (1993), this study limited its focus to only examining the perspectives of a specific stakeholder group - experienced IT project managers. However, even though not specified, the study could have included respondents from different cultural backgrounds, as highlighted by Schmidt *et al.* (2001) and Keil *et al.* (2002) as an important factor that impacts risk perception.

Through a review of existing literature and structured interviews with 18 IT project managers, Baccarini *et al.* (2004) derived a list of 27 risk factors which was then ranked in terms of its likelihood and consequences. The top five risk factors in order of priority include:

1. Personnel shortages;
2. Unrealistic timelines and budget;
3. Unrealistic expectations;
4. Vague or unclear requirements; and
5. A diminished window of opportunity due to late delivery of software.

Similar to the study done by Alter & Ginzberg (1978), Boehm (1991), Barki *et al.* (1993), and Addison & Vallabh (2002), data was collected mainly from project managers and did not take the risk perceptions into account of stakeholders external to the organisation, such as end-users.

Another study done by Tesch *et al.* (2007) that was also limited to the risk perceptions of 23 project managers across a variety of organizations (industrial, government, and consulting), categorised six risk factors through structured interviews:

1. Sponsorship/ownership;
2. Funding and scheduling;
3. Personnel and staffing;
4. Scope;
5. Requirements; and
6. Relationship management.

To accommodate for different perceptions on risk across cultures Schmidt *et al.* (2001) conducted a rigorous Delphi study that involved participants from Hong Kong, the USA, and Finland. Participants were requested to identify and rank risk factors in terms of their relative importance. The study produced a rank ordered list of 11 risk factors that plague Information System (IS) projects.

1. Absence of top management commitment to the project;
2. Insufficient user commitment;
3. Misunderstood the requirements;
4. Lack of adequate user involvement;
5. Poorly managed end user expectations;

6. Changing scope/objections;
7. Insufficient knowledge/skills in the project personnel;
8. Lack of frozen requirements;
9. Introduction of new and complex technology;
10. Insufficient or inappropriate staffing; and
11. Cross- department conflicts.

Acknowledging that the research done by Schmidt *et al.* (2001) only considered project managers within developed countries (Hong Kong, the USA, and Finland), Liu *et al.* (2010) conducted a Delphi study in China that extended beyond only the risk perceptions of project managers, and also considered risk perceptions of senior executives. The top 10 risk factors per stakeholder group is presented in Table 2.1 below.

Table 2.1: Top ten risks from Liu et al. (2010)

#	Senior Executive	Project Managers
1	Lack of top management commitment to the project	Lack of top management commitment to the project
2	Disconnect between organization culture and required business process changes	Unclear/misunderstood requirements
3	Project implementation has a major impact on organizational structure	Project implementation has a major impact on business processes
4	Project ownership and senior management changes	Frequent changes to scope and requirements
5	Ignoring business requirement due to technology	Poorly identified requirements
6	Inaccurate system requirements	Lack of system capability and requirements by users
7	Project implementation has a substantial effect on business processes	Project implementation is heavily influenced by organisational structure
8	New and complex technology is deployed in the project	Inaccurate system requirements
9	Organisational politics motivated the project	Poor or ineffective cooperation and support from users

10	Ineffective project management methodology	Limited user participation

Extending on these studies, Keil *et al.* (2002) studied the different perception project managers and users have on risks through a similar Delphi study that utilized the 53 risk factors identified by (Schmidt *et al.*, 2001). The different perceptions from the two participant groups are presented in Table 2.2 below.

Table 2.2: Top ten ranked risk from Keil et al. (2002)

	Users	**Project Managers**
1	Ineffective development process	Lack of top management support
2	Unclear definition of roles and Responsibilities	Misunderstood requirements
3	Poor or inadequate user involvement	Poor change management
4	Unavailability of skilled personnel	Lack of user commitment
5	Unfavourable team relationships	Limited project management skills
6	Misunderstood requirements	Poor user involvement
7	Lack of proper/adequate planning	Poorly managed end user expectations
8	Improper staffing arrangements	Ineffective project management methodology
9	Lack of adequate skills/knowledge and experience in project personnel	Inadequately understood scope and/or objectives
10	Disagreements/conflict between user departments	Changes to scope and/or objectives

Extending on the above research done by Schmidt *et al.* (2001) and Liu *et al.* (2010), Smith *et al.* (2006) explored risks experience in IT projects within the South African context. Forty surveys were completed by experienced and inexperienced software project managers. The top ten risks identified were:

1. Absence of top management commitment to the project;
2. Unclear/misunderstood scope/objectives;
3. Unrealistic schedules;
4. Lack of client ownership and commitment of the project;

5. No planning or inadequate planning;
6. Unclear business case;
7. Absence of available skilled personnel;
8. Poor change management;
9. No or low user involvement; and
10. Poor risk management.

Although the risks identified do align with previous research, four unique risks were identified within the South African context: 1) no or inadequate planning; 2) projects are not based on a sound business case; 3) lack of available skilled personnel, and 4) not managing change properly. Similar to previous studies reviewed, the data was collected from project managers only and does not include risk perspectives from other stakeholders.

Even though not explicitly restricted to risks, Marnewick & Labuschagne (2009) also conducted a study within the South African context, where factors that influence the outcome of IT projects were analysed. Two-hundred and six respondents, representing various industries in South Africa, participated in the survey. Thirteen factors were identified that have a strong impact on IT project outcomes:

1. Insufficient communication between team and customers;
2. Absence of top management support;
3. Poor change management;
4. Inadequate user involvement;
5. Unclear business objectives;
6. Unclear requirement definition;
7. Misaligned user understanding of technology;
8. Poor change control processes;
9. Not understanding the users' needs
10. Communication between project team members;
11. Formal methodologies;
12. Project manager expertise; and
13. Support for innovative technology.

Extending on the above studies that identified typical risks in IT projects within South Africa, Javani & Rwelamila (2016) conducted a quantitative study to explore the status of risk management in IT projects within the South African public sector, especially since IT project failure rates are still high. Three research questions were defined:

1. Is risk management recognised as a knowledge base among IT project experts?;
2. To what extent is risk management applied in current IT projects?; and
3. To what extent is risk management understood by IT project clients?

Their findings give significant statistical support to conclude that risk management is being applied in current IT projects and is understood by the corresponding project clients. However, although the importance of risk management is acknowledged, its acknowledgement as a knowledge base between IT project individuals is low. Furthermore, Javani & Rwelamila (2016) concluded that although public organisations apply a full risk assessment when each IT project starts and risk management throughout subsequent phases, no systematic approach exists in the literature to address risks within the organisation. Lastly, they found that although risk management is understood by corresponding project clients, there is minimal communication between the project team and the client.

Studies from Schmidt *et al.* (2001), Keil *et al.* (2002), Smith *et al.* (2006), Marnewick & Labuschagne (2009), and (Liu *et al.*, 2010) set a good foundation to understand how risks differ between cultures and across roles. Although there are common risks that were identified across cultures and stakeholders, these studies highlight the importance of being cognisant of varying risk perceptions when analysing risk factors that impact IT project success and failure.

Extending on studies done by Alter & Ginzberg (1978); Boehm (1991); Barki *et al.* (1993); (Baccarini *et al.*, 2004); Tesch *et al.* (2007), and Hoermann *et al.* (2012) emphasised the inconsistencies in previous literature regarding the ranking of IT project risks, and suggested that a project's risk profile is dependent on the type of project being investigated. Through a German-based Delphi study, Hoermann *et al.* (2012) found that although project-generic risks are encountered across different IS projects, project type-specific risk exerts a considerable influence on a project's risk profile. Table 2.3 presents the top 3 ranked risks per project type.

Table 2.3: Top Risk factors from Hoermann et al. (2012)

Project type	**Top three risks**
Internally Driven IS Development	Dependencies on other projects
	Availability of testing infrastructure
	Unclear requirements
Externally Driven IS Projects	Unstable requirements

	Delayed business concepts
	Lack of personnel
Implementation of Standard Software Projects	Lack of personnel
	Complexity of Interface
	Low project priority

Hoermann et al. (2012) concluded that although there are generic risks that occur across the three types of IT/IS projects, there are also project specific risks that significantly influence the project's risk profile. This suggests that certain types of projects are more susceptible to certain risks.

Substantial effort has been spent on identifying risks frequently encountered in IT/IS projects. Most of the work focused solely on the risk perceptions of project managers. A few studies considered different perceptions by including participants other than project managers.

Schmidt *et al.* (2001) criticized a lack of consideration of cross-cultural perspectives in previous studies. The study considered cultural dimensions, such as Power distance, Uncertainty avoidance, Individualism, and Masculinity, which influence the perceptions of risks amongst participants from Hong Kong, the USA, and Finland. Liu *et al.* (2010) acknowledged that these studies did not consider cultures from developing countries and were also limited only to accommodating the risk perceptions of project managers. Liu *et al.* (2010) therefore explored the risks within China which involved both the risk perceptions of project managers and senior executives. Extending on this, Keil *et al.* (2002) also considered the role of the participants and distinguished between project managers' and users' perceptions of risks. Studies done by Smith *et al.* (2006), Marnewick & Labuschagne (2009), and (Javani & Rwelamila, 2016) aimed at understanding the risks in IT projects within developing countries, specifically South Africa.

Project risk management requires proactively working with a variety of stakeholders to minimize the probability of risks associated with project decisions (Didraga, 2013, Loosemore *et al.*, 2006). It is also important to understand that each of these project stakeholders perceives risks differently (Addison & Vallabh, 2002, Boehm, 1988, de Camprieu *et al.*, 2007, Mursu *et al.*, 2003, Schmidt *et al.*, 2001). Risk is socially grounded and stakeholders derive their understanding of risks, and attitudes towards them, mainly from the society in which they live and work (Edwards *et al.*, 2020). This highlights the importance of analysing project risks based on specific factors such as culture or stakeholder roles that impact the risk perceptions of participants.

Besides considering culture and stakeholder roles, Hoermann *et al.* (2012) suggested analysing risk based on the type of IT project. The study distinguished between internally driven IS development projects, externally driven IS projects and implementation of standard software projects.

Based on more recent studies (post 2000) the more commonly occurring risk factors (unranked) based on the frequency of discussion in extant literature are summarised in Table 2.4 below.

Table 2.4: Summary of most cited risk factors

	(Schmidt *et al.*, 2001)	(Keil *et al.*, 2002)	(Addison & Vallabh, 2002)	(Baccarini *et al.*, 2004)	(Smith *et al.*, 2006)	(Tesch *et al.*, 2007)	(Marnewick & Labuschagne, 2009)	(Liu *et al.*, 2010)	(Hoermann *et al.*, 2012)
Lack of top management support/commitment	✓	✓	✓		✓	✓	✓	✓	✓
Lack of user involvement/ expectation management	✓	✓	✓	✓	✓		✓	✓	
Misunderstanding/unclear requirement	✓	✓	✓	✓	✓	✓	✓	✓	✓
Continuous/unreasonable change of scope/objectives	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lack of effective project management		✓	✓		✓		✓	✓	
Personnel shortfalls and lack of skill	✓	✓		✓	✓	✓	✓		✓
Technical complexity/ newness of the technology	✓						✓	✓	

The studies reviewed so far analysed shared risks that occur in most IT projects. However, they do not necessarily address their relative importance when compared to each other.

Matavire *et al.* (2010) addressed this gap in research by applying a grounded theory approach to investigate the relationships between factors that affect eGovernment implementation. The research incorporated three high level objectives: 1) identify the dominant factors affecting eGovernment implementation, 2) the relationship between these factors, and 3) how the key concerns can be resolved. The challenges and contributing factors are ranked by importance and presented in Table 2.5 below.

Table 2.5: Factors that affect eGovernment implementation (Matavire *et al.*, 2010)

Ranking	**Challenges**	**Contributing factors**
1	Leadership	1. Leadership structure 2. Government performance measurement system 3. Continuity of leadership 4. Sustained interest
2	Fragmentation of projects	1. Financial systems fragmentation 2. Service fragmentation 3. Legislative fragmentation
3	Appreciation of perceived IT value	1. Perceive IT as a cost or tool rather and not aware of potential benefit
4	Citizen inclusion	1. Hierarchical structures are not compatible with the social inclusivity required
5	Tasking scheduling conflict	2 Task priority 3 Task cooperation

Although this approach did address the gap in the literature by addressing the relationships and relative importance of challenges in eGovernment implementation, it did not clearly define which of these should be addressed first in order to support successful project delivery.

To address the causal relationships of software development project risks across the software development lifecycle (SDLC), Hijazi *et al.* (2014) reviewed common risks identified in previous studies and tasked developers, project managers and academics to discuss the cause and effect relationship between each identified factor using an Ishikawa diagram (or Fishbone diagram). These factors were then categorised/grouped into the specific SDLC phase it affects. The idea is to allow project managers and developers to implement suitable risk management strategies to deal with the maximum number of risk factors early on in the SDLC. The top risks that mainly drive other risks are presented in Table 2.6 below.

Table 2.6: Important risks within the SDLC (Hijazi *et al.*, 2014)

#	SDLC phase	Important risks
1	Requirement analysis and definition	• Inadequate estimation of project time, cost, scope and other resources • Unclear project scope and requirements • Insufficient resources • Non-verifiable requirements
2	Design	• High system complexity • Complicated Design
3	Implementation and unit testing	• Inexperienced Programmers • Lack of complete automated testing tools
4	Integration and system testing	• Component integration • Unqualified testing team • Too many requirement changes
5	Operation and maintenance	• Change in environment

Extending on the previous research, Kanjanda & Tuan (2020) also argued that the majority of studies adopted a reductionist approach and emphasised three issues 1) previous studies believe that IT project risk factors are independent, 2) only a few studies considered risk factors within developing countries, and 3) the subjective nature of risks was not always taken into account. Adopting an Interactive Management (IM) approach six main risk drivers were identified:

1. Limited computer literacy;
2. Poor communication;
3. Lack of executive support;
4. The complexity of design;

5. Bureaucracy; and
6. Employee turnover.

In light of the studies done by Matavire *et al.* (2010), Hijazi *et al.* (2014) and Kanjanda & Tuan (2020), it becomes clear that risks differ significantly across cultures and stakeholders, and by understanding the relationships between risks, primary risk drivers can be defined for a specific project environment.

The literature discussed so far considered risk across a variety of IT projects and highlighted the subjective nature of risks, cultural impact on risk perceptions, and relationships between risks and the primary drivers. Due to the unique nature of MAD projects the next section will specifically review the literature on risks within mobile application development (MAD) projects.

2.3 Risks mobile application development projects

Various studies to date explored typical risks within traditional software engineering environments and projects. Although several of these risks can apply to MAD projects, there are some additional and distinctive components to consider when exploring risks in MAD projects and environments (Flora & Chande, 2013, Flora *et al.*, 2014a, Flora *et al.*, 2014b, Wasserman, 2010). The previous section reviewed common risk factors in IT projects which could potentially be transferred to MAD projects. The remainder of this chapter will review studies that specifically focused on important risks that plague MAD projects.

One of the major risks within MAD projects that was emphasized early on relates to security and privacy. Although security and privacy risks associated with desktop environments still prevail, mobile environments present new and unique security attack challenges that developers and organisations need to acknowledge and monitor (Ghosh & Swaminatha, 2001). Insecure mobile applications can have severe consequences on organisations which can lead to critical information security and privacy concerns (Jain & Shanbhag, 2012). In a report investigating millions of monthly security tests during 2016, 4% of mobile devices have malware, of which Android devices are nearly twice as likely to have malware compared to Apple devices (Skycure, 2016). A more recent report, (Samani, 2020) identified click fraud, fake reviews, and malvertising, which new and hidden methods malicious hackers use to access device data and functionality. One of the most appealing features of smartphones is the availability of a wide variety of apps for users to download and install, which makes these devices more vulnerable to security attacks (He *et al.*, 2015):

1. **Personal data stored on the device:** e.g., financial transaction information from online shopping or online banking will give hackers substantial financial gain, which makes smartphones attractive targets;

2. **Open-source platforms**: Android’s open-source kernel provides hackers with an opportunity to gain a deeper understanding of the platform, which makes cyber-attacks easier on such platforms; and
3. **User impressions:** when users perceive their smartphones as a mere mobile devices with a variety of software to facilitate communication and entertainment, little attention is given to security measures that makes cyber-attacks easier.

It is therefore clear that security and privacy remain prevalent risks within MAD projects. Dwivedi *et al.* (2010) elaborated on this risk category by discussing the top risks that mobile devices face in terms of security and privacy. These are presented in Table 2.7. The authors do note that this list is not exhaustive nor is it in order of priority.

Table 2.7: Important MAD security and privacy issues from Dwivedi *et al.* (2010)

	Security/privacy issue	**Description**
1	Physical security	Besides the lost costs of the physical device being stolen, the information on the device is now available to a potentially malicious party or individual.
2	Secure data storage	This relates to the first issue and includes the ability to store that sensitive data locally (on the device itself) securely, as well as to keep it accessible to the applications that need it to function properly.
3	Strong authentication with poor keyboards	Using industry standards for password authentication (such as a combination of letters, numbers and characters) is not always applicable or viable on mobile device keyboards.
4	Multiple-user support with security	Traditional client operating systems (such as iOS, GMS, and HMS) support multiple users; however, their architectures gives each user a different operating environment, each with their security model.
5	Safe browsing environment	This mainly relates to the lack of real estate on mobile screens which makes it easier for scammers to display only parts of the URL or even allow the browsing URL to be hidden completely.

6	Secure operating systems	This relates to how well the mobile device vendors address security issues that will directly impact the user experience
7	Application isolation	Different applications on devices require access to different types of data. Data needs to be secure from applications that are not intended to access specific data on the device e.g., gaming applications should not have access to corporate documents stored on the device.
8	Information disclosure	Besides the loss of data residing on the device when it is stolen, access from the device to other networks is another factor of concern.
9	Virus, worms, trojans, spyware, malware	Mobile environments provide opportunities for new kinds of security attacks that developers need to be aware of.
10	Difficult patching/update process	When a specific mobile device (e.g., Samsung) runs a custom version of the Android operating system, and a software update needs to be released, the device provider needs to coordinate with the mobile network carriers (e.g., MTN or Vodacom) for a proper release cycle to ensure the update does not break other applications that function on top of that.
11	Strict use and enforcement of SSL	Older mobile devices cannot enforce Secure Sockets Layer (SSL). Newer devices do have the ability to enforce SSL, and therefore developers and device makers need to incorporate backwards compatibility in their software that support both older and newer devices.
12	Phishing	Phishing is a cyber-attack that targets mobile device users (via email, SMS etc.) by posing as a legitimate institution to lure individuals into providing sensitive data such as personally identifiable information, banking and credit card details, and passwords.

13	Cross-site request forgery (CSRF)	CSRF is an attack class that commonly affects web applications and permits an attacker to modify a victim's personal information on vulnerable applications without the user's knowledge.
14	Location privacy/security	The use of a GPS, location software, or simply one's social media page to alert friends about one's whereabouts introduces a new level OS security issue that was not necessarily a concern for desktop and most laptop operating systems.
15	Insecure device drivers	Mobile operating systems incorporate an array of strong security measures to protect against system-level access to the operating system. Nevertheless, if third-party software provides a means to get around these protection schemes via their insecure code, the device will be exposed to attackers.
16	Multifactor authentication	Mobile devices can fall into the hands of any person, either on purpose or accidentally and therefore mobile web applications need multifactor authentication to protect sensitive information that can be accessed via the device. Furthermore, with no device storage and little information available, mobile web applications are incapable of providing robust MFA

In a comprehensive security assessment mainly focussed on the Android operating system, Shabtai *et al.* (2010) acknowledge the significance of security risks as a result of the open-source approach followed by this operating system. They identified the below risks:

1. Viruses and other malware;
2. Services that are exposed to insecure networks;
3. Fraud and strange telephone activity;
4. Harm caused by malicious applications;
5. Unauthorized device use;
6. Unneeded permissions that attackers can maliciously exploit;
7. Identity verification and eavesdropping;
8. Device theft;

9. Denial of services (DoS);
10. Violations of confidential content; and
11. Offline tampering.

Theoharidou *et al.* (2012) criticized previous research by arguing that most studies focus mainly on expert opinions and therefore suggested taking the smartphone user's perspective into account and presented a personalised risk assessment model. The qualitative case study focussed mainly on Android devices since it held over 52% of the market sales in quarter three of 2011 (Theoharidou *et al.*, 2012). The risk assessment model collected data from a single user and identified eight medium-to-high security and privacy risks presented in Table 2.8.

Table 2.8: User's perspective on security and privacy risks (Theoharidou *et al.*, 2012)

Risk	**Description**
Eavesdropping	When mobile carriers do not have strict security measures and hackers access the device voice services to listen in on conversations
Unauthorized device (physical) access	When data on the device can easily be accessed by other parties due to inadequate password protection
Unauthorized access	When the device source code is used by an attacker to gain unauthorised access to the device with administrator privileges
Crashing	When the device is running on a *buggy* version of Android which affects the device performance and access to data
Sensitive information disclosure	Attackers use spyware to access sensitive data such as the device call history
Corrupting or modifying private content	When storing data to an external device (such as a laptop) from the smartphone the files can become corrupted, and data compromised
Client-side injection/malware	When users unknowingly download malware that affects most software security attributes on the device
Direct billing	When malicious applications abuse the internet permissions to incur direct costs to the use

Extending on this research Mylonas *et al.* (2013) also considered the user's perspective and stated that users have varied risk perceptions and therefore perceive the impact of disclosure to personal information differently. However, there are general risks that users agree on which is summarised in Table 2.9.

Table 2.9: User's perspective on security and privacy risks from Mylonas *et al.* (2013)

Risk	**Description**
Tracking/surveillance	Monitoring the user's activity by using the device's sensors such as GPS
Interception/eavesdropping	This relates to the unlawful interception of communications and applies to all communication data types
Profiling	refers to user activity monitoring, but for advertising purposes
Phishing	This refers to tricking the user to disclose sensitive information such as personally identifiable information, banking and credit card details, and passwords
Personal information disclosure	Refers to the disclosure of private information such as documents, digital files, etc.

The majority of research on security and privacy risks focused mainly on the Android operating system due to the increased security risk as a result of the platform's open-source approach as well as the variety of available data, which makes it easier for hackers to access the data (Mylonas *et al.*, 2013, Shabtai *et al.*, 2010, Theoharidou *et al.*, 2012). Table 2.10 presents commonly occurring risk factors (unranked) based on the frequency of discussion in extant literature around security and privacy risks.

Table 2.10: Summary of MAD security and privacy risk literature

	(Dwivedi, 2010)	**(Shabtai, 2010)**	**(Theoharidou, 2012)**	**(Mylonas, 2013)**
Unauthorised device use (physical)	✓	✓	✓	
Different operating system	✓		✓	
Application data access and permissions	✓	✓		
Personal information disclosure	✓	✓		✓

Virus/Malware/Spyware attacks	✓	✓	✓	
Phishing (SMS/Email attacks)	✓	✓		✓
Device location access	✓			✓
Eavesdropping			✓	✓

Extending beyond security and privacy issues, Jha (2007) developed a risk catalogue that consists of known and potential problems in MAD projects. The main purpose of the risk catalogue is to serve as a testing guideline for quality assurance in mobile applications that result in project failure. The risk catalogue was divided into four categories presented in Table 2.11.

Table 2.11 Mobile application risk catalogue (Jha, 2007)

Risk category	**Risk elements**
Product elements	Includes elements such as code structure. Functions, data, platforms, and synchronization.
Operational quality criteria	Includes elements such as capability, dependability, usability, security, scalability, compatibility, and performance.
Development quality criteria	Includes elements such as supportability, testability, maintainability, and scalability.
Project Environment	Customer, information, team, deliverables, schedules, and tools.

In acknowledging the unique aspects of MAD projects when compared to traditional IT projects König-Ries (2009) highlighted three challenges that are related to the unique design dimensions of mobile applications as summarised in Table 2.12.

Table 2.12: Challenges related to the unique design dimensions of mobile applications

Challenge	**Description**
Architecture	Mobile devices generally have restricted capabilities and programming interfaces. Their underlying architecture is also highly heterogeneous.

Data and context management	The main concern here is to know what data is being stored on the device and how it is synchronized to a centralized server. Additionally, there is also an assumption that users are constantly connected to the internet or respective network.
User interface	The user interface on smartphone devices are completely different from desktop devices and needs to be considered when developing a mobile application.

Dehlinger & Dixon (2011) argue that MAD projects are unique from traditional software development projects based on three novel factors: 1) mobile device user interface, 2) divergent mobile platforms (such as iOS and Android), and 3) novelty of a truly mobile computing platform. Based on these unique factors, Dehlinger & Dixon (2011) defined four different types of unique challenges that exist in MAD projects and environments presented in Table 2.13 below:

Table 2.13: Four unique challenges that exist in MAD projects (Dehlinger & Dixon, 2011)

Unique challenge	**Description**
Creating universal user interfaces.	Each mobile platform has different guidelines to address developer user interface requirements. These guidelines also have several overlapping themes.
Enabling software reuse across mobile platforms.	Mobile applications involve various operating systems, hardware makers, delivery methods, and computing platforms each with its unique guidelines. This makes the reuse of code across different platforms complicated.
Designing context-aware mobile applications.	Mobile devices are highly customized and organisations must continuously monitor their environment, thus making mobile applications inherently context aware.

Balancing agility and uncertainty in requirements.	Factors such as context-aware applications, competition between mobile applications, and low acceptance from users for unstable mobile applications, require that developers incorporate a semi-formal approach into existing agile engineering processes.

Kakkar *et al.* (2013) also studied the challenges in traditional software development and presented different aspects of risk management in mobile applications. Risk management is identified as an important factor to manage the constant changes and challenges in MAD projects. Table 2.14 presents the unique and important risks within MAD projects.

Table 2.14: Mobile application development project risks from Kakkar *et al.* (2013)

Risk	**Description**
Customer related risks	Sufficient customer research is necessary to accurately understand their requirements. Poor research will lead to misinterpretation by the project team which heightens the probability of this risk factor
Communication related risks	To ensure the developers and testers have a good understanding of what the client requires communication needs to be streamlined
Market risks	These risks relate to existing competitors, the client's purchasing power, and issues related to the user interface. In-depth market research is required to proactively manage this risk factor.
Resource risks	The dependencies and availabilities across different resources need to be considered. Resources can be classified as stakeholders' investments, developers, designers, and selected platforms.
Financial risks	Cost valuation and budget control play a vital role in the development of all mobile applications.
Technical risks	These include user interfaces, testing strategies, algorithms, and platforms. To proactively manage this risk, organisations generally offer a Beta version of the application to early adopters who can uncover technical weaknesses and give valuable user feedback.
Managerial risks	Managers are under constant pressure to rapidly roll out new software to improve efficiency and provide new functionality. At times this can lead to different scenarios not being considered, and the application is exposed to instability and security risks.
Performance risks	Different operating system providers such as Android and iOS have their approaches to validate software weaknesses and deal with external threats.
Maintenance risks	Frequent updates to the software are rolled out and the team responsible for maintaining the product needs to be updated on what these changes were.
External risks	Testers must consider a variety of situations that are external to the application that could have an impact on its performance. For example, different internet connections in different countries.

In a non-empirical study, Sahd & Rudman (2016) argue that there is a divide between the governance of MAD technology and the risks involved. Important risks are therefore not addressed effectively as a result of governance policies being implemented in an ad hoc manner. Furthermore, (Sahd & Rudman, 2016) categorised important risks in two levels: 1) strategic risks resulting from a lack of governance; and 2) operational risks arising from the technology itself. Table 2.15 summarises these risks.

Table 2.15: Significant risks arising from mobile technology (Sahd & Rudman, 2016)

Risk category	**Risk subcategory**	**Description**
Strategic		A lack of board-level involvement and structured governance in the development of strategies and processes to mitigate the significant risks.
Operational	Interoperability	Mobile technology components can struggle interoperating (in terms of data exchange, communication, collaboration and storage) when exposed to complex environments.
	User experience	The ability to deliver the benefits of improved productivity, communication is dependent on users' satisfaction with the device and the mobile software
	Connectivity	The disjointed nature of current wireless network systems has created complex systems that are difficult to maintain.
	IT support	The wide variety of device types, related versions of operating systems and applications make technical support in a mobile environment challenging.
	Security	Mobile devices are more vulnerable to theft or loss and wireless networks are more exposed to malicious attack and interception.
	Cost	The deployment of mobile technology has substantial cost implications such as device investment and the cost of enabling technologies.
	Data ownership	In a mobile environment, it becomes challenging to control data that can be easily accessed and shared on devices that are not owned or controlled by the enterprise

Through systematic literature review (SLR) Dar *et al.* (2018) highlighted software requirements elicitation techniques and the challenges in mobile application development. One of the research questions aimed at identifying exactly what the requirement gathering challenges are while developing mobile applications. Table 2.16 provide eight categories of challenges experienced during requirement-gathering activities based on their finding.

Table 2.16: Requirement-gathering challenges (Dar *et al.*, 2018)

Category	**Examples**
Stakeholders	User involvement
Requirements	Prioritisation Skills
Communication	Articulation Understanding of stakeholder needs Verbal and presentation abilities
Knowledge and skills	Problem analysis Domain related
Change management	Changes to acceptance criteria Changes in user needs
Scope related	Unclear scope definition
Human factors related	Conflict
Social, organisational related	Policy Structure Organisational culture

In another empirical study, Ahmad *et al.* (2018) investigated the challenges experienced by mobile application developers when building either native, web-based, or hybrid mobile applications. These challenges are further mapped to specific knowledge areas as specified by the Software Engineering Body of Knowledge (SWEBOK). Table 2.17 summarises their finding.

Table2.17: SWEBOK knowledge areas and identified challenges (Ahmad *et al.*, 2018)

Knowledge area	**Challenges**
Software requirements	1. Change management
Software design	2. Fragmentation 3. Compatibility
Software construction	4. Reuse of code 5. Lack of tools supported
Software testing	6. Testing
Software engineering management	7. Lack of expertise
Software quality	8. User experience 9. Security
Software engineering professional practice	10. Lack of training 11. Lack of team-ness 12. Lack of knowledge management 13. Lack of communication

Through an online survey with experienced developers, Flora *et al.* (2014a) examined the challenges that can impact mobile application performance and distinguish between hardware related and software related challenges as presented in Table 2.18.

Table 2.18: Mobile application challenges (Flora *et al.*, 2014a)

Risk category	**Description**
	Hardware related
Cross platform compatibility	They are multiple mobile platforms that companies need to consider when designing and developing an application
Varying hardware complexities	Device capabilities, such as processing, power, and memory capacity are limited when compared to desktop computers.
	Software related
Inexperienced resources	When building the application, developers need to be concerned with following style guidelines and understand the different behaviours of each device.
Insufficient & uncertain requirements	Projects can easily derail when requirements are not clearly defined.
Budget and Schedule	When approval or funding processes are delayed the budget and schedule can be impacted.
User Experience (UX)	User interaction is different from desktop applications and involves gestures, sensors, and location data
User Interface (UI)	Devices have limited screen space and applications must be designed to make use of available screen space most effectively.
User input technology	User input can be generated not only from the user (via the keyboard), but also from other sources such as GPS and cameras
Form factors	Devices with small form factors are limited to the amount of data they can display.
Data access	Mobile devices can access data from backend databases and need to monitor lost connections and restore data once the connection resumes.
Delivering quality applications	Users respond negatively toward low-quality apps. Comprehensive testing and reviews are required before releasing to the users.
Complexity of testing	Testers should not only rely on test emulators and include testing on actual devices. The complexity comes in when identifying which devices to test on.

Analysing the target users	Understand the target markets that will benefit from the mobile application and design it around them.
Security and Privacy	Insecure applications can provide opportunities for attackers to access unauthorised information stored on the device.

Through a survey targeting mobile application developers (Wasserman, 2010) highlighted additional risks that are not frequently found in a traditional software application that is presented in Table 2.19.

Table 2.19: Unique challenges in MAD projects (Wasserman, 2010)

Unique challenge	**Description**
Interaction with other applications	Possible interaction with other applications stored on the device
Sensor handling	Respond to the movements of the device and the gestures for the touch screen.
Native and Hybrid applications	Invoke services from the internet, affecting the data, the display, or even the performance of the device.
Software and hardware compatibility	Application interactions with device hardware such as GPS, Camera, or messages
Security	Avoid malware that can affect the overall performance of the device.
User interfaces	Adhere to the user interface guidelines implemented in the software development kits (SDKs).
Complexity of testing	Test using device emulators, automated testing and manual testing.
Power consumption	Affects the power consumption of the device and hence causes a serious threat to the device's battery life

Studies from Jha (2007), Wasserman (2010), Dehlinger & Dixon (2011), Kakkar *et al.* (2013), Flora *et al.* (2014a) and Ahmad *et al.* (2018) extended beyond the realm of privacy and security risks to identify additional risks unique to MAD projects. However, the research identified risks that stem mainly from data input from developers or project managers. It failed to incorporate the input from other stakeholders such as management, end-users, or consultants. Many studies highlighted the subjective nature of risks and argued that risks differ due to a variety of factors such as culture and stakeholders with different jobs (Boehm, 1988, de Camprieu *et al.*, 2007, Kanjanda & Tuan, 2020, Mursu *et al.*, 2003, Schmidt *et al.*, 2001). This raises the concern of the potential bias involved or scope limitation inherent within the studies reviewed in this section.

Other studies have directed their focus more towards the mobile users and highlighted usability as one of the key factors in product quality and, if not given enough emphasis, could cause various usability problems which can impact the failure of the product (Dey & Häkkilä, 2008, Hutahaean *et al.*, 2020, Ketola, 2002). These usability problems are caused by usability risks. Usability risk is defined as a risk that results from the use of a particular technology that impacts the usability of a system and negatively affects the user experience (Dey & Häkkilä, 2008). Usability risk is not related to the technical quality of the product (which can be addressed during technical product testing), but rather emphasises the issues arising from product use that leads to users abandoning the brand (Ketola, 2002). To address and manage usability risk, proper and good requirements are necessary, which are defined in the early stages of developing the information system (Hutahaean et al., 2020). The table below provides a summary of risk factors to be considered early on during the product development stages to address usability risks as presented by Hutahaean *et al.* (2020) in Table 2.20.

Table 2.20: Usability risks to be considered for MAD projects (Hutahaean *et al.* (2020)

Risk factor	**Risk description**	**Affected usability attribute**
Inadequate estimation of project time, cost, scope and other resources	Unrealistic project schedules, budgets, unclear scope and insufficient resources, have serious consequences and are considered to be the main causes of project failure.	Effectiveness
Unclear project scope	Unclear scope can lead to many core functions being missed and additional ones being considered and result in project failure	Efficiency
Unrealistic schedule	Unrealistic schedule adds time constraints and burdens the developer to deliver on time in an unrealistic way and for the project may exceed the agreed delivery date.	Efficiency

Unrealistic budget	The estimated cost for the project can surpass the agreed upon budget and, if not addressed, the project runs out of funds at the start of the SDLC and fails.	Efficiency
Insufficient resources	Lack of skilled resources can delay the projects, leading to higher costs or lower quality.	Efficiency

Based on studies reviewed in this section the more commonly occurring risk factors in MAD projects (unranked) based on the frequency of discussion in extant literature included are summarised in Table 2.21 below.

Table 2.21: Summary of most cited MAD project risk factors

	(Jha, 2007)	**(König-Ries, 2009)**	**(Dehlinger & Dixon, 2011)**	**(Kakkar *et al.*, 2013)**	**(Sahd, 2015)**	**(Dar *et al.*, 2018)**	**(Ahmad *et al.*, 2018)**	**(Flora *et al.*, 2014a)**	**(Wasserman, 2010)**	**(Hutahaean *et al.*, 2020)**
Customer experience		✓	✓	✓	✓		✓	✓	✓	
Market fragmentation				✓	✓		✓		✓	
Stakeholders -investment				✓		✓	✓			
Project team members				✓		✓	✓	✓		✓
Architecture	✓	✓	✓	✓	✓		✓	✓	✓	
Security	✓			✓	✓		✓	✓	✓	
Internet connection		✓		✓	✓			✓		
Project management	✓		✓	✓		✓	✓			
Scope definition and changes	✓			✓		✓				✓
Knowledge				✓		✓	✓	✓		✓

2.4 MAD project risk research summary

A wide variety of research focuses mainly on security and privacy risks since insecure mobile applications can lead to significant information security and privacy issues and can have severe consequences for organisations and projects (Jain & Shanbhag, 2012). Other studies stretched beyond security and privacy issues to consider other risk factors that can impact the MAD project's performance. The sample group from these studies was mainly homogenous in that they either only collected feedback from developers, project managers, or users. The studies did not necessarily incorporate heterogenous views into a single study. Different risk perspectives are important to consider due to the subjective nature of risks (Barki *et al.*, 1993, Keil *et al.*, 2002, Liu *et al.*, 2010). Furthermore, little attention was given to the cultural context that can impact MAD projects. Since numerous studies stated that risks vary based on factors such as culture (Kanjanda & Tuan, 2020, Marnewick & Labuschagne, 2009, Schmidt *et al.*, 2001, Smith *et al.*, 2006), there is an evident gap in existing literature in light of MAD environments. Although previous research provides a good starting point for understanding risks unique to MAD environments, an opportunity still exists to incorporate different stakeholder perceptions and consider cultural factors that impact MAD projects into research.

MAD projects and environments are complex due to the constant change in user needs, expectations and market players (Dar *et al.*, 2018, Flora & Chande, 2013, Flora *et al.*, 2014a, Wasserman, 2010). The research reviewed focussed mainly on identifying and ranking risks that are unique to MAD projects. Little attention is given to understanding the relationship that exists between these risks. Dar *et al.* (2018) did take a systematic approach as a result of the complex nature in MAD projects and suggested different requirement gathering techniques to assist with risks management. However, the study did not highlight the relationships that exist between risk factors. Numerous studies argue that risks should not be analysed in isolation since they interact dynamically in a non-linear manner and are therefore essentially dependent (Ackermann *et al.*, 2007, Ambrósio *et al.*, 2011, Büyüközkan & Ruan, 2010, Lopes *et al.*, 2015, Yang *et al.*, 2014). This highlights the importance of understanding the relationships that exist between risks to ultimately identify the core drivers of risk, instead of analysing risks separately. With this being said, existing studies mainly take on a reductionist approach. The reductionist paradigm generates knowledge by understanding phenomena by breaking it down into smaller components and then analysing these components separately (Flood, 2010). White (1995) stated that most risk assessment methods presented in the literature are underpinned by this approach to problem-solving. Furthermore, Ackermann *et al.* (2014) argue that this type of approach fails to consider situations where one risk aggravates or magnifies another, a phenomenon referred to as emergence (Ackermann *et al.*, 2014). Finally, based on previous studies done on risks within IT projects it is clear that personal perceptions of risks, the cultural context, and the relationships that exist between risks need to be considered. These three factors were not highlighted in the existing literature on risks within MAD projects.

This chapter started with an overview of what risks are and how they are managed. It then continued by reviewing existing literature around more traditional IT projects and highlighted important aspects that need to be considered. Although these risks and aspects can be transferred to MAD projects there are unique aspects and risks to be considered in MAD projects. Existing research on MAD projects were then reviewed and compared with the vast research done to date on traditional IT projects. Finally, three elements were highlighted to be lacking in MAD projects literature; risk perceptions, cultural aspects, and the relationships between risks.

The subsequent chapter will elaborate on the complex nature of MAD projects and environments, and why a reductionist approach will not be appropriate to understand the core risk drivers that exist in MAD environments. Furthermore, appropriate approaches will be discussed, and the research methodology will be defined.

CHAPTER 3: Research methodology

3.1 Complex nature of projects

The previous chapter reviewed the literature on risks in traditional software development projects and elaborated on unique risks that plague MAD projects. This chapter will address the inherent complexity within MAD projects and propose an appropriate research approach for exploring MAD project risks.

The development of mobile applications is still believed to be complex, and the methods and techniques typically used are insufficient (Flora & Chande, 2013, Flora *et al.*, 2014a, Flora *et al.*, 2014b, Wasserman, 2010). Furthermore, various issues exist that add to the complexity of these types of projects; 1) customer needs change often and require continuous assessment (Flora *et al.*, 2014a), 2) new standards emerge rapidly, irregular device connectivity occurs, a wide variety of devices exist, platforms are volatile at times, and user interface and input technology vary across devices and platforms (Flora *et al.*, 2014b), and 3) the dynamic nature of MAD environments lead to different development and technical requirements for various applications, making it challenging for developers and quality assurance engineers (Zhang & Adipat, 2005).

Although the performance of IT projects has been the subject of research for decades, these projects (and by extension MAD projects) are still underperforming (Joseph, 2017). Between 80-90% of mobile applications published in the mobile app stores are deserted after first-time use (Goyal, 2019). In addition, more than half of the mobile applications in the Google Play store have almost no downloads. Over 60% of applications with a decent amount of downloads faced a drop rate of 80% in the first week and will never be used again (Petrov, 2016).

Recent studies on IT project failures have expanded this paradigm, taking the complexity and scale of multifaceted projects as root causes (Al-Ahmad *et al.*, 2009). The reductionist approaches described in the previous section explain that risk areas and their impacts can be identified and reviewed at project initiation and throughout the project lifecycle to increase the likelihood of success. However, the major frameworks used do not help to understand the fundamental nature of system complexity inherent in complex adaptive systems (Checkland & Poulter, 2010, Jackson, 2016, Kanjanda & Tuan, 2020, White, 1995, Whitney & Daniels, 2013). Complex adaptive systems (CASs) cause complex system behaviour due to the numerous loosely interconnected autonomous components or agents that interact with each other. (Kautz, 2012, Vidgen & Wang, 2009). Furthermore, CAS is rooted in the assumption that changes in systems are not linear and easily predictable (Schroeder & Hatton, 2012). Even with optimal development methodologies, complex IT projects always have complex issues, and should therefore be treated as complex adaptive systems. (Schroeder & Hatton, 2012, White, 1995, Whitney & Daniels, 2013).

To improve the success of IT projects, Xia and Lee (2004) proposed a classification model (see Figure 3.1) to categorize the complexity of systems in such environments. They argued that by measuring these major dimensions, project managers were able to understand how project outcomes would be affected.

Figure 3.1: Taxonomy of information systems project complexity

Organisational vs. Technological	Structural Organisational Complexity	Dynamic Organisational Complexity
	Structural Information Technology Complexity	Dynamic Information Technology Complexity
	Structural	**vs. Dynamic**

The dimensions in Figure 3.1 can be defined as follows:

1. **Structural organisational complexity -** describes nature and strength of the relationships between the organizational environment and project elements;
2. **Structural information technology complexity -** depicts the relations between the IT elements;
3. **Dynamic organisational complexity -** measures the patterns and rate of change in the IS organisational environment; and
4. **Dynamic information technology complexity -** which measures the patterns and rate of change in the technology environment.

Using a web-based survey of 541 participants in IS development projects, Xia and Lee (2004) concluded that the complexity of IS projects has a negative impact on project performance. Furthermore, they also found that organizational complexity has a greater impact on the performance of information systems projects than that of technical complexity. These findings emphasize the importance of understanding information systems projects and the organizational environment to explore how to reduce the high failure rate of information systems projects. By considering the multidimensional aspects of project complexity through a comprehensive literature review, Joseph (2017) identified five project complexity constructs that are summarized in Table 3.1 below.

Table 3.1: IS project complexity dimensions identified from Joseph (2017)

Complexity dimension	**Description**	**Complexity elements**
Organisational complexity	Complexity linked to the organisation itself	• Vertical differentiation or organisational hierarchy • Horizontal differentiation or number of units within an organisation • Size • Project team • Trust • Risk • Interdependencies
Technical or technological complexity	The complexity surrounding the technology or technical aspects of projects	• Differentiation in the diversity of project inputs and outputs • Project goals • Project scope • Diversity of project tasks • Experience of project teams • Project risks
Environmental complexity	Complexity is linked to the volatility of the environment in which the organisation operates.	• Diversity of project stakeholders • Location • Market conditions • Risks
Uncertainty	Complexity is linked to the uncertainty of the current and future states of different elements.	• Conventional project constraints (time, scope and cost) • Project activities • Project goals • Technology • Stakeholders • Available project information
Dynamics	Complexity surrounding project change management methods and processes.	• Project change management

Cardenas *et al.* (1997) viewed complexity through the interrelationship between three elements: 1) situational complexity, 2) cognitive complexity, and 3) pluralistic complexity. Situational complexity refers to the complexity that surrounds the variety of elements involved in a problem situation and their interactions and behaviours (Cardenas *et al.*, 1997). Cognitive complexity refers to the human mental endeavour in conceptualizing reality and refers specifically to the aspects of human understanding of a specific situation that makes interpretation difficult (Cardenas *et al.*, 1997, Tuan, 2002). Furthermore, a system of constructs that differentiates highly between people can be seen as cognitive complexity (Bieri, 1955). Factors such as personal values, culture, past experiences, and attitude can determine how people view a specific situation (Lyles, 1981). Considering that risk perceptions are influenced by different cultures or stakeholder roles (Keil *et al.*, 2002, Liu *et al.*, 2010, Schmidt *et al.*, 2001), it is clear that cognitive complexity is an important factor to be considered when exploring risks within MAD projects and environments. Pluralistic complexity is a socio-psychological dimension that acknowledges the multiple interpretations of complexity in situations where multiple individuals are involved, and is usually concerned with human interaction challenges such as communication (Cardenas *et al.*, 1997, Tuan, 2002).

A systems-thinking approach will be useful to explore and define the performance issues inherent within these projects given the complex nature of information systems development projects, and by extension MAD projects, (Ackermann *et al.*, 2014, Burke, 2011, Jackson, 2016). Systems thinking is described as a holistic approach to solving complex problems, while analytical methods used in risk assessment can be viewed mainly as reductionist (White, 1995). System thinking acknowledges the interrelated nature of components and its emerging behaviour (Flood, 2010). However, it is important to note that the appropriate systems approach depends on the context of the problem, which is characterized by the different values and beliefs of the participants in the face of complex environment (Jackson, 2016).

This section emphasizes the complexity of the project, analyses the different factors that contribute to the complexity of the project, and proposes a systems-thinking approach. The following sections will describe the different systems-thinking methods and propose the most appropriate methods for understanding the inherent complexity associated with risks in MAD projects and environments.

3.2 Systems approach for addressing the complexity of MAD projects.

By describing two contrasting images of project management practice, Winter & Checkland (2003) distinguished between a hard system approach and a soft system approach. Hard system approaches require situations to have clear objectives and a clearly defined management process, usually defined as a sequence of life-cycle stages (Winter & Checkland, 2003). In contrast to this, soft system approaches involve continuously evolving situations where the end and means are not always clear, especially in the early stages of the project. Furthermore, it requires a cyclic management process guided by situations and based on intuition and experience (Winter & Checkland, 2003).

Reynolds (2011) recommended that systems are defined based on their ontology, epistemology, and intention. *Ontology* described the beliefs around the nature of 'things' or 'being'. The *epistemology* of a systems approach describes the beliefs on how knowledge is generated. Lastly, the *intention* of a systems approach is concerned with the primary pledge or human purpose embodied within the specific approach.

3.2.1 Hard systems approach

The *ontology* of this systems approach adopts realism and believes that the 'real world' is made up of different systems and subsystems. In terms of *epistemology*, this approach acknowledges that validity is based on 'objective' scientific methods. Finally, this approach intends to establish control and enable technical mastery. Examples of hard systems approaches include general system's theory, classic 'mechanistic' cybernetics, system's engineering, and system's dynamics (Reynolds, 2011). Although this approach is effective in assisting project managers and organisations to optimize the performance of a system through the pursual of clearly identified goals (Checkland & Poulter, 2010, Jackson, 2016), it does have some weaknesses:

1. This approach relies mainly on a single observer's viewpoint and does not effectively address complex systems that are made up of various stakeholders with different viewpoints making it unable to cope with a plurality of different beliefs, values, and perceptions (Jackson, 2016, Ntshangase, 2017, Reynolds, 2011);
2. This approach disregards the human aspect of systems and treats people as components that need to be manipulated to achieve a single objective, instead of actors (with different objectives) that influence the behaviour of the system (Jackson, 2016); and
3. This approach includes systems modelling which involves simplification of complex problems. In these situations, the complexity is not often clear and simplification can involve some degree of bias (Jackson, 2016).

3.2.2 Soft systems approach

This approach incorporates multiple observers' viewpoints and requires the participation of multiple stakeholders involved in taking action as well as the stakeholders affected by it (Flood, 2010). This approach involves an action-orientated process to explore a specific problem where participants learn by understanding the situation and taking action to improve it (Checkland & Poulter, 2010). Based on Reynolds (2011) interpretation of system approaches, the *ontology* of this approach adopts nominalism and believes systems are means of representing phenomena. In terms of *epistemology*, this approach believes that knowledge is socially constructed and subjective, aligning with constructivist and interpretivism beliefs. The *intention* of this enables furthering communication and understanding between different groups. Examples of soft systems approaches include inquiring systems design, soft systems methodology (SSM), cognitive mapping, and interactive management(IM) (Reynolds, 2011).

3.2.3 Critical systems approach

Based on Reynolds (2011) interpretation of system approaches, and similar to a soft systems approach, this approach accepts nominalism and believes systems are a means of embodying phenomena. The epistemology of critical systems reflects constructivist and critical idealism and believes knowledge is socially constructed. The phenomenon is filled with human purposes, and their views and purposes must therefore be subject to critical reflection (Reynolds, 2011). Critical systems heuristic was created by Ulrich & Reynolds (2010) and supports reflective practice by presenting twelve boundary questions based on:

1. **Sources of influence:** motivation, control, knowledge, and legitimacy;
2. **Boundary judgements based on social roles:** beneficiaries, decision-makers, experts, and witnesses;
3. **Specific concerns:** purpose, resources, expertise, and emancipation; and
4. **Key problems:** Improvement measures, decision environments, and worldviews.

Although this approach acknowledges that knowledge is socially generated and supports the critical reflection of human purposes, it has been criticized in literature (Jackson, 2016):

1. This approach neglects to consider the social structures of the system and the positions of stakeholders, which is very important to explain the ideas they hold; and
2. This approach does not present a social theory to effectively question where the social boundaries should be drawn.

3.3 Appropriate systems approach for exploring risks in MAD projects

Given the complexity, pluralistic and coercive nature of MAD projects and environments (Flora & Chande, 2013, Flora *et al.*, 2014a, Flora *et al.*, 2014b, Wasserman, 2010), coupled with the goal of this study to explore dominant risks within these projects, a soft system approach will be more appropriate given the following reason:

1. Research done by Xia & Lee (2004) and Carvalho & Rabechini Junior (2015) indicates that the organisational "soft" side has an impact on the technological "hard" side. This is not catered for in a hard systems approach.
2. MAD projects and environments are influenced by a wide variety of stakeholders with different values, beliefs and cultures (Javani & Rwelamila, 2016, Keil *et al.*, 2002, Liu *et al.*, 2010, Marnewick & Labuschagne, 2009, Schmidt *et al.*, 2001), a hard system approach will not be effective as it relies on a single observer's point of view (Jackson, 2016, Reynolds, 2011);
3. A soft system approach intends to discover purpose and incorporate various viewpoints. Therefore it will be appropriate as it incorporates various viewpoints from diverse participants within MAD project environments (Reynolds, 2011);
4. Soft systems recognize that knowledge is socially constructed and subjective (Reynolds, 2011) which can address the cognitive issues that impact project success (Cardenas *et al.*, 1997, Tuan, 2002).
5. The emancipation nature of critical systems neglects to incorporate power structures in social systems and has been criticized as too idealistic in literature (Jackson, 2016).

Given the above points, as well as the continuing challenges facing MAD projects and the environment, a soft system approach to modelling the complexity of MAD projects based on risk will help to discover new issues that affect project performance. The following section will provide an overview of soft systems approaches and supports Interactive Management (IM) as a suitable method to effect such a change.

3.4 Examples of soft systems approaches

3.4.1 Soft System Methodology (SSM)

SSM is a soft system approach that deals with situations where people are active subjects and have unclear goals. In addition, it involves asking questions at a strategic level, aiming to understand a previously unstructured situation, not to solve a well-structured problem (Platt & Warwick, 1995). To solve this type of problem situation, Checkland & Poulter (2010) propose drawing a rich picture of the situation to better understand the various elements/components that make up this soft system. The purpose of this rich picture is to informally capture the main entities, structures and opinions in the situation, ongoing processes, currently recognized problems and potential problems (Checkland & Poulter, 2010). Winter & Checkland (2003) considered using models to structure discussions about specific situations depicted in the rich picture and how they can be improved, resulting in the SSM learning cycle. In revising the classical SSM learning cycle described above, Checkland & Poulter (2010) defined seven principles and five actions to consider when making sense of complex situations. The seven principles are:

1. Real-world problems are problematic situations that individuals consider requiring action or attention;
2. The problem situation is moulded by the worldviews (Weltanschauungen) of individuals that participate in these discussions;
3. All real-world problematic situations include individuals acting purposefully and with intent;
4. Discussions about the problematic situation can be structured using models that trigger questions and generate knowledge about the circumstances;
5. To take action to improve these situations requires accommodation amongst different world views;
6. This is a never-ending inquiry process that facilitates continuous learning amongst participants; and
7. SSM involves critical reflection not only about the situation itself but also about the thinking and world views behind it.

Furthermore, five actions are valuable when aiming to understand complex and problematic situations (Checkland & Poulter, 2010):

1. Understand the initial situation that is considered problematic by mapping out a rich picture;
2. Develop some purposeful activity models that are considered relevant to the situation;
3. Use these models to question the real-world situation and identify changes that are both desirable and culturally appropriate in a particular situation; and
4. Continuously define the action to be taken to realize required changes.

It is important to note that the SSM learning cycle is not defined as a sequence of steps, but rather as an ongoing process whereby activities occur simultaneously across ‘steps’ (Winter & Checkland, 2003). Although SSM is suitable for complex and diverse environments, it has been criticized in the literature for resolving conflicts in a coercive environment because it does not attempt to link the worldview with the realm of social power that exists amongst stakeholders (Jackson, 1990, Jackson, 2016, Reynolds, 2011). Furthermore, it is argued that SSM practitioners often advocate for a ‘meta-methodology’ status that, in turn, incorporates a hard systems approach as a part of SSM (Flood & Jackson, 1991).

3.4.2 Interactive Management (IM)

Another example of a soft systems approach developed by John N. Warfield is interactive management (IM), a systemic methodology that can be used to identify risks and facilitate team productivity, especially in complex situations (Alexander, 2002, Janes, 1988, Kanjanda & Tuan, 2020, Ntshangase & Tuan, 2019, Warfield & Cárdenas, 1994). The purpose of IM is to subjectively understand different points of view and objectives of a variety of project stakeholders (Alexander, 2002, Jackson, 2016). The outcomes of this approach can be organized in three major categories (Warfield & Cárdenas, 1994):

1. **Definition:** defining and understanding a complex problem, issue, or situation;
2. **Alternative designs:** construct alternative designs for addressing the complex problem, issue, or situation; and
3. **Choice of design:** participants review alternative designs and agree on the most appropriate one.

The outcomes are addressed through different interactions with participants that have different perspectives of the problem situation or issue. When identifying participants it is important to consider whether they are truly representative and knowledgeable about the situation at hand; do not merely strive towards a specific 'sample size' (Ntshangase & Tuan, 2019). The facilitator guides participants through workshops to provide feedback in order to achieve the three main outcomes as defined by (Warfield & Cárdenas, 1994). These workshop sessions can vary in length and can be short and only take a couple of hours or be longer and take a couple of days. This depends on the number of elements to be debated amongst representatives (Kanjanda & Tuan, 2020). The IM approach typically consists of four phases (Alexander, 2002, Kanjanda & Tuan, 2020, Ntshangase & Tuan, 2019, Warfield & Cárdenas, 1994):

1. **Idea generation** – The facilitator presents triggering questions to the participants to ultimately define a list of risk factors they perceive as important. These questions can be presented via a questionnaire where 6-12 participants are required to list important risk factors.
2. **Idea clarification** – the purpose of this phase is to clarify different ideas and align different terminology used between participants to describe similar concepts. Firstly, participants ensure there is a shared understanding of the meaning of each risk, and secondly, they are tasked to rank the risks in order of importance.
3. **Idea structuring** – the purpose of this phase is to understand what, if any, the relationships are that exist between the ordered list of risks. A risk relationship diagraph is developed through Interpretive Structural Modelling (ISM) tools such as computer programmes that use binary matrix algorithms containing system elements/components. Contextual relationships are defined

by how a pair of elements relate to each other within the problem situation being examined. An example of a contextual relationship is ‘significantly gives rise to’, where the problem being explored could be related to understanding how component A significantly gives rise to component B. Furthermore, if B significantly gives rise to C, it can be inferred that A significantly gives rise to C. Where relationships exist, the facilitator assigns it “1”. Where no relationship exists between a pair of components, it is assigned “0”. The facilitator guides the participants through a pair-wise comparison process whereby the values are entered into the ISM programme to develop a diagraph.

4. **Idea interpretation** the purpose is for all participants to review the diagraph and have a clear understanding of the core risk drivers and what the action plan is to address the problem situation. Should the participant question some of the relationships the process reverts to phase 3 to update the pair-wise comparison between components. This is an iterative process that only ends when there is an agreement amongst participants.

Finally, an Interactive Management approach is considered as the most appropriate method for understanding the complexity that exists within MAD projects and environments due to the following reasons:

1. IM provides the structural benefits of hard systems approach while not being limited to the organisation’s social structures (Alexander, 2002);
2. Like SSM, IM incorporates different stakeholder perspectives. However, IM has the additional benefit of also taking social areas of power into consideration, which SSM has been criticized for lacking (Alexander, 2002, Jackson, 1990, Jackson, 2016, Reynolds, 2011);
3. IM incorporates cooperative team participation into the decision-making process and can free participants from coercion (Alexander, 2002); and
4. Knowledge generated throughout the IM process is primarily refined through ‘multiplicative corroboration’, providing appropriate guidance to take action to address the complex problematic situation (Tuan, 2002).

3.5 Research design

This study will adopt soft systems approach using the Interactive Management (IM) approach consisting of four stages: 1) planning – this involves preparing for the workshops and defining the components that are required to ensure successful interactions (Warfield & Cárdenas, 1994), 2) workshop – the facilitator leads the conversation amongst participants to support a structured intervention (Alexander, 2002, Warfield & Cárdenas, 1994), 3) follow-up – facilitator compiles a suitable action plan to effectively deal with issues that were discussed within the workshop

(Alexander, 2002), and 4) implementation – execute the plan of action to effectively deal with issues that were raised (Alexander, 2002). The focus of this study will be on the planning and workshops phases to identify dominant risks and the relationships that exist between them. With this in mind, the implementation phase of IM will therefore not be part of the scope of this study. Within the context of this research the planning phase includes defining the research problem, research questions, defining the questionnaire in terms of the IM phases discussed in the previous section, identifying the appropriate workshop participants, and obtaining their consent upon ethics approval. Within the workshop and follow-up phase the IM phases will be carried out. These phases will be described in the subsections (IM process) that follow. The finding of each of these phases will be discussed in more detail in the following chapter.

3.6 Planning

3.6.1 Problem statement

Industry statistics indicate that MAD project still experiences high failure rates and most applications that do make it to the online application stores are eventually abandoned after a single use. Furthermore, the complexity of MAD projects is multi-faceted and MAD project environments have contextual and unique project risks inherent in their environments that make them more complex. Although some research was done to identify and list important risks that exist in MAD environments and projects, little attention has been given to understanding the interrelationships that exist between these risks and what the main risk drivers are that lead to project failure.

3.6.2 Ethics clearance

The research proposal was submitted for ethics review on 13 March 2021 and was declined at first, requiring minor updates to be made to the participant consent form. The updated consent form was resubmitted on 5 May 2021 and approved on 6 May by the University of Cape Town Faculty of Engineering and Built Environment. The ethics approval form is included in Addendum A of this research report. Furthermore, informed consent was required from the workshop participants and a consent form had to be signed by each participating member. The template of the consent form is provided in Addendum B of this research report.

3.6.3 Questionnaire design

The purpose of the questionnaire is twofold: 1) to identify appropriate participants for the IM workshops, and 2) to elicit ideas that will be discussed during the workshops. Therefore, the questionnaire was structured into two sections. Section 1 captures background information of each participant that describes their experience and role within MAD projects. Section 2 requires them to identify risks they perceive as important and affect project success.

When identifying workshop participants, Ntshangase & Tuan (2019) suggested that instead of striving for a certain 'sample size', researchers should rather be concerned with whether the participants are truly knowledgeable and representative to feedback on the problem being examined. To identify the appropriate stakeholders Achterkamp & Vos (2007) suggested using boundary critique. This boundary technique was also endorsed by authors such as Jackson (2007) and Ulrich (1983) who noted that boundaries define coherently what the issues are and who is involved in dealing with these issues. Furthermore, Achterkamp & Vos (2007) defined stakeholders as groups or individuals who can affect, be affected, or perceive to be affected by the project outcome. With this in mind, Achterkamp & Vos (2007) distinguish between actively involved parties and passively involved parties. For this study six to 11 participants will be identified in line with the system roles as defined by Achterkamp & Vos (2007):

1. **Actively involved** – any party involved that can affect the project objectives;
2. **Client** – any party whose purposes are being served through the project;
3. **Decision maker** – individuals who have the power to set project requirements and evaluate whether the requirements are met;
4. **Designer** – any party that provides expertise within the project and is responsible for the deliverables; and
5. **Passively involved** – any party involved that can be affected by the project objectives without being able to influence the process or outcomes.

The questionnaire was distributed using Google Forms, and the template of the questionnaire is available in Addendum C of this research report.

3.7 IM process

The IM approach will comprise the following phases (Kanjanda & Tuan, 2020, Ntshangase & Tuan, 2019, Warfield & Cárdenas, 1994):

3.7.1 Idea generation

The purpose of this phase is to ask triggering questions to elicit feedback on important risks that exist in MAD projects and environments. In light of time constraints, this was actioned through an online questionnaire. The questionnaire consists of two sections: 1) participant identification, and 2) risk identification. The output of this phase will provide details on each participant's background and experience within MAD projects as well as a combined list of all the risks across participants.

3.7.2 Idea clarification

The purpose of this phase is to get a shared understanding of the meaning behind the most important risks. This was conducted through an online video call with all the participants present. They are presented with the combined list generated through the previous phase to rephrase or remove vague risk factors. The output of this phase is a shared understanding amongst participants and an ordered list of dominant risks.

3.7.3 Idea structuring

The purpose of this phase is to structure the relationship between dominant risks using Interpretive Structural Modelling (ISM). ISM transforms poorly defined perceptions about a problem situation into a model that facilitates a better understanding of a complex problem (Warfield & Cárdenas, 1994). This was executed through another video call where participants were presented with trigger questions such as '*does risk X give rise to risk Y*', to guide discussions on the contextual relationships that exist between the identified dominant risks. A pair-wise comparison of all the MAD project risks will be conducted in this way. The output of this phase was a risk diagraph portraying the risk relationships and highlighting the dominant risk drivers.

3.7.4 Interpretation

The purpose of the final phase is to develop a shared understanding amongst participants about the main risk drivers that impact MAD project success. The final interaction will be done via a video call. Participants review the generated diagraph and amendments are made where requested. This phase will be iterative and collaborative until the participants develop a shared understanding of the generated ISM model.

This chapter explored the complex nature of projects, highlighting different factors that contribute to the complexity of the project, and proposes a systems-thinking approach. Different systems thinking approaches for understanding complex situations were explored and soft systems approach, specifically interactive management (IM) was proposed. The research design was further described in terms of how it relates to the problem statement and research questions, as well as the IM process that will be followed. The following chapter will present the data that was captured during the data collection phase and how it relates to the literature that was reviewed in chapter 2.

CHAPTER 4: Research findings and discussion

4.1 Stakeholder identification and classification

When identifying IM workshop participants it is important to note that the aim of the soft system approach is not to discover a universal law but rather to learn from the situations and find a consensus amongst group participants (Ntshangase & Tuan, 2019). Therefore, participants should not be considered as human subjects and it is not accurate to refer to the "sample size" to indicate the number of representatives in the group (Ntshangase & Tuan, 2019). Furthermore, Tuan (2004) suggested that to unravel "messy situations" group participants are required collaborate and provide versatile solutions that produce larger varieties. IM group workshops typically consist of 6-12 participants that have knowledge on a specific issue or situation (Warfield & Cárdenas, 2002).

To align with the problem situation (i.e., MAD environment) stakeholders were identified by distributing a consent form via email that describes the research purpose, nature of participation, and acknowledgement of anonymity and commitment to participate in the study which is presented in Addendum B. These individuals are either working for an established mobile application development organisation or are end-users of the mobile payment application product that is available on Apple Store, Google Play, and Huawei App Gallery. This is in line with the suggestion from Warfield & Cárdenas (1994) to have a broad stakeholder representation that includes key interest groups. Furthermore, Yang *et al.* (2014) suggests that organisations need to understand problems between projects and externl stakeholders to ultimately avoid the effects of external forces that can negatively impact project outcomes.

A total of 10 participants indicated an interest in the research by signing the consent form of which eight participants completed the survey. The participants that did not complete the survey were excluded from the remainder of the research process. The online survey (using Google forms) prompted feedback on the roles of each participant and what risks they perceive as important. Section 1 of the questionnaire includes questions involving the participants' roles and section 2 of the questionnaire required each participant to list six risk factors that negatively impact project outcomes. The questionnaire template is presented in Addendum C. The eight participants were broadly representative and included internal and external stakeholders. This is in line with the suggestion from Warfield & Cárdenas (1994) to have a broad stakeholder representation that includes key interest groups. Furthermore, this will account for the subjective nature of risks which involves different perspectives of risk that differ between cultures and across roles (Addison & Vallabh, 2002, Boehm, 1988, de Camprieu *et al.*, 2007, Mursu *et al.*, 2003, Schmidt *et al.*, 2001). This study will mainly focus on different risk perspectives within MAD projects between different stakeholder roles. For this study eight participants were identified in line with the system roles as defined by Achterkamp & Vos (2007):

1. **Actively involved** – any party involved that can affect the project objectives;
2. **Client** – any party whose purposes are being served through the project;
3. **Decision -maker** – individuals who have the power to set project requirements and evaluate whether the requirements are met;
4. **Designer** – any party that provides expertise within the project and is responsible for the deliverables; and
5. **Passively involved** – any party involved that can be affected by the project objectives without being able to influence the process or outcomes.

Table 4.1 below describes the stakeholders in terms of their experience within MAD project environments, provides a personal description of their day-day tasks, which is then linked to the role categorisation as presented by Achterkamp & Vos (2007).

Table 4.1: Participant's role description and classification

Participant	**Years of experience**	**Role description (personal)**	**Stakeholder roles as defined by Achterkamp & Vos (2007)**
Participant 1	<1	Estimating work effort and development.	Actively involved
Participant 2	4	Quality assurance and application testing, bug logging and automation testing.	Actively involved
Participant 3	7	Overseeing the product development roadmap and project prioritization; representing and providing context around business requirements; consultant to product, marketing and design decisions.	Actively involved & Decision maker

Participant 4	4	Design system interfaces and layouts to accommodate for an effective and comfortable mobile user experience. Report back to product team on findings and design solutions. Create marketing and media content for user education and awareness.	Actively involved & Designer
Participant 5	9	Maintaining and adding to an existing mobile project on Android	Actively involved
Participant 6	9	Design and engineer software solutions for the mobile application on Android and iOS.	Actively involved & Designer
Participant 7	2	Defining the roadmap, design and functional requirements	Actively involved & Decision maker
Participant 8	0	N/A	Passively involved & Client

The majority of the participants were categorised as Actively involved. These individuals actively work on designing, developing, testing and releasing the mobile application product. These stakeholders include developers, testers, graphic designers, and product managers. Decision makers' role is to ensure the current and upcoming work assigned to the teams is aligned with the strategic goals of the organisation and evaluate whether the project outcomes did meet the business objectives. These individuals include product managers. The designers' role is to provide expertise on the potential solution from a back-end architecture perspective as well as from a front-end graphical design. These individuals include technical team leaders and graphic designers. Lastly, one participant can be defined as Passively involved and Client. This individual does not have any power over the processes and outcomes but is rather served by the outcome of the project. The average experience amongst the participants is just over five years. The lowest experience is six months with nine years being the highest amount of experience. The following section will provide feedback on the second part of the survey which focused on the typical risks identified by participants that they perceive have a negative impact on project delivery.

4.2 Idea generation

The main focus of section 2 of the questionnaire was to get an understanding of the risks that negatively impact MAD project outcomes. Table 4.2 provides a summary of risks from each participant together with their stakeholder role classification. The unmodified questionnaire responses can be found in Addendum D.

Table 4.2: Participant risk identification

Participant	**Risk factors identified**	**Stakeholder category**
Participant 1	1. Technical debt 2. Poor communication 3. Misalignment of technical and business objectives 4. Unknown time sinks due to technical debt 5. Team asymmetry/work coordination 6. Key man reliance	Actively involved
Participant 2	1. Project scope creep 2. Unclear requirements and deliverables 3. Resource reliance and capacity 4. Unclear understanding of the end-users' needs 5. Project scope size 6. Poor internal team communication	Actively involved
Participant 3	1. Requirement analysis; 2. Quality control 3. Test coverage 4. Technical debt 5. Cross-departmental collaboration 6. Responsibility assignment	Actively involved & Decision maker
Participant 4	1. Poorly researched market and audience 2. Poor user experience 3. Lack of effective communication within the team 4. Lack of originality 5. Not choosing a platform wisely 6. Improper testing	Actively involved & Designer
Participant 5	1. Third party dependency 2. Misunderstanding the platform 3. Transparency with the end user and controlling their expectations 4. Marketing exposure 5. Timing of technology and market readiness 6. Developers' capabilities	Actively involved

Participant 6	1. Over-commitment 2. Loosely defined requirements 3. Key man reliance 4. Focus context switching 5. Late demonstrations of work done to stakeholders 6. Scope creep	Actively involved & Designer
Participant 7	1. Unavailability of data to understand user behaviour 2. Multiple device types and sizes that are released by mobile phone manufacturers	Actively involved & Decision maker
Participant 8	1. Failure to define the project scope correctly 2. Failure in proper communication or project and operational environment transparency 3. Human resources not performing as expected 4. Insufficient operational structures 5. Scope creep from management	Passively involved & Client

The survey provided 28 risks which are presented in Table 4.3. Risks that were frequently listed included: 1) Poor internal communication, 2) Scope creep, 3) Key man reliance, and 4) Unclear requirements. Other noteworthy risks included 1) Technical debt, 2) Poor external communication, 3) Team collaboration and coordination, 4) Poor understanding of end users' needs, 5) Quality control, and 6) Team skills and capabilities.

Table 4. 3: Risks frequency matrix

Risk ID	Risk	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8
R1	**Tech debt**	✓		✓					
R2	**Poor internal communication**	✓	✓		✓				✓
R3	**Poor external communication**	✓	✓						
R4	**Market readiness for technology**					✓			
R5	**Misalignment with business objectives**	✓							
R6	**Team collaboration and coordination**	✓		✓					
R7	**Platform knowledge**					✓			
R8	**Scope creep**		✓				✓		✓
R9	**Key man reliance**	✓	✓				✓		
R10	**Poor understanding of end users' needs**		✓		✓				
R11	**End user’s expectation management**					✓			
R12	**Size of releases**		✓						

R13	**Unclear requirements**			✓			✓		✓
R14	**Quality control**			✓	✓				
R15	**Test coverage**			✓					
R16	**Work assignment**			✓					
R17	**Bad user experience**				✓				
R18	**Lack of innovation**				✓				
R19	**Chosen platforms and tools used**				✓				
R20	**Third party dependencies**					✓			
R21	**Marketing exposure**					✓			
R22	**Team skills and capabilities**					✓			✓
R23	**Inadequate task estimation**						✓		
R24	**Work interruptions**						✓		
R25	**Timing of demos to stakeholders**						✓		
R26	**Data to understand user behaviour**							✓	

R27	**Number of devices in the market**							✓	
R28	**Operational structures**								✓

4.3 Idea clarification

The purpose of this phase is to obtain a shared understanding of what each risk means. The list from the previous phase was used to kick off the discussion for idea clarification. This list was presented to the participants during three online video calls where the group was asked to collectively agree on the meaning of each risk. A total of 28 risks were presented during the video calls of which 11 risks were retained as is, 18 risks were rephrased, five risks were split, and one was removed. Upon discussion, it was decided that 'Operational structures' does not necessarily lead to a negative impact on the project outcome, specifically in the context of this mobile payment app development environment. The final list included a total of 34 risks that are presented in Table 4.4 below and will be further analysed in the subsequent phase of idea structuring.

Table 4. 4: Group definition of each risk with reference to literature

Risk ID	**Risk name**	**Description**	**Amendments after clarification**	**Reference in traditional software development literature**	**Reference in MAD project literature**
R 1	A large amount of technical debt	A large cost of additional work as a result of choosing the easiest solution that meets the minimum viable requirement, or third-party system updates, or poor system maintenance.	Rephrased description		(Kakkar *et al.*, 2013)
R 2	Poor internal communication	Not communicating frequently and effectively within and across teams.	Retained as is	(Kanjanda & Tuan, 2020, Marnewick & Labuschagne, 2009)	(Ahmad *et al.*, 2018, Dar *et al.*, 2018, Kakkar *et al.*, 2013)
R 3	Poor external communication	Not communicating frequently or effectively with external partners.	Retained as is	(Kanjanda & Tuan, 2020, Marnewick & Labuschagne, 2009)	(Ahmad *et al.*, 2018, Dar *et al.*, 2018, Kakkar *et al.*, 2013)

R 4	Poor communication with the market	End users do not understand how to use the product.	Split from timing of technology and added to the list	(Addison & Vallabh, 2002, Alter & Ginzberg, 1978, Kanjanda & Tuan, 2020, Keil *et al.*, 2002, Liu *et al.*, 2010, Marnewick & Labuschagne, 2009, Schmidt *et al.*, 2001, Smith *et al.*, 2006)	(Dar *et al.*, 2018, Flora *et al.*, 2014a, Jha, 2007, Kakkar *et al.*, 2013)
R 5	Poor timing of the technology	New features can fail as a result of incorporating technology that is too new and not properly supported by external platforms or hardware.	Rephrased description	(Alter & Ginzberg, 1978, Barki *et al.*, 1993, Liu *et al.*, 2010, Marnewick & Labuschagne, 2009)	
R 6	Powerful stakeholders that are bias	These stakeholders are either external or internal to the organization and put pressure on the team to deliver features that are not aligned with the core objectives of the organization.	Rephrased and split from the initial risk of misalignment with business objectives	(Kanjanda & Tuan, 2020, Liu *et al.*, 2010, Tuan, 2002)	
R 7	Lack of understanding of business objectives	The team does not understand the business objectives and can define solutions and deliver features that are not aligned with the business objectives.	Rephrased and split from the initial risk of misalignment with business objectives	(Addison & Vallabh, 2002, Keil *et al.*, 2002, Marnewick & Labuschagne, 2009, Smith *et al.*, 2006)	(Sahd & Rudman, 2016)

R 8	Poor research on market readiness	Lack or insufficient understanding of the readiness for the technology to be released into the market and adopted by end-users.	Rephrased and split from the initial risk of unclear requirements	(Addison & Vallabh, 2002, Marnewick & Labuschagne, 2009)	(Flora *et al.*, 2014a)
R 9	Poor research on end-user needs	Lack or insufficient research to understand the user needs when using the application.	Rephrased and split from the initial risk of unclear requirements	(Addison & Vallabh, 2002, Alter & Ginzberg, 1978, Hoermann *et al.*, 2012, Keil *et al.*, 2002, Liu *et al.*, 2010, Marnewick & Labuschagne, 2009, Schmidt *et al.*, 2001, Smith *et al.*, 2006)	(Dar *et al.*, 2018, Flora *et al.*, 2014a, Hutahaean *et al.*, 2020, Kakkar *et al.*, 2013)
R 10	Poor team collaboration	Working in isolation and not involving the required individuals at the stages of delivering the new feature where they are needed.	Rephrased and split from the initial risk of team collaboration and coordination	(Addison & Vallabh, 2002, Liu *et al.*, 2010, Matavire *et al.*, 2010)	(Ahmad *et al.*, 2018, Dar *et al.*, 2018, Flora *et al.*, 2014a, Hutahaean *et al.*, 2020, Jha, 2007, Kakkar *et al.*, 2013)
R 11	Poor coordination	Poor or lack of proper project planning.	Rephrased and split from the initial risk of team collaboration and coordination	(Addison & Vallabh, 2002, Keil *et al.*, 2002, Liu *et al.*, 2010, Marnewick & Labuschagne, 2009, Matavire *et al.*, 2010,	(Ahmad *et al.*, 2018, Dar *et al.*, 2018, Hutahaean *et al.*, 2020, Jha, 2007, Kakkar *et al.*, 2013)

				Smith *et al.*, 2006)	
R 12	Lack of platform knowledge	Lack of understanding of the platforms we use in building the product.	Retained as is	(Addison & Vallabh, 2002, Keil *et al.*, 2002, Schmidt *et al.*, 2001)	(Ahmad *et al.*, 2018, Dar *et al.*, 2018)
R 13	Lack of process knowledge	Poor understanding of processes used in building and delivering the product.	Split from the initial risk of platform knowledge	(Addison & Vallabh, 2002, Keil *et al.*, 2002, Schmidt *et al.*, 2001)	(Ahmad *et al.*, 2018, Dar *et al.*, 2018)
R 14	Lack of domain knowledge	Lack of technical knowledge on how the product interacts with the larger system	Split from the initial risk of platform knowledge	(Addison & Vallabh, 2002, Keil *et al.*, 2002, Schmidt *et al.*, 2001)	(Ahmad *et al.*, 2018, Dar *et al.*, 2018, Flora *et al.*, 2014a)
R 15	Lack of business context knowledge	Poor understanding of how the product interacts with its environment, including stakeholders.	Split from the initial risk of platform knowledge	(Addison & Vallabh, 2002, Keil *et al.*, 2002, Schmidt *et al.*, 2001)	(Ahmad *et al.*, 2018, Dar *et al.*, 2018)
R 16	Scope creep	Frequent changes and additions to the release scope.	Retained as is	(Addison & Vallabh, 2002, Hoermann *et al.*, 2012, Keil *et al.*, 2002, Liu *et al.*, 2010, Marnewick & Labuschagne, 2009, Schmidt *et al.*, 2001, Smith *et al.*, 2006, Tesch *et al.*, 2007)	(Dar *et al.*, 2018, Hutahaean *et al.*, 2020, Jha, 2007, Kakkar *et al.*, 2013)

R 17	Key man reliance	When we rely too heavily on the knowledge or ability of one person to perform key functions.	Retained as is	(Addison & Vallabh, 2002, Baccarini *et al.*, 2004, Barki *et al.*, 1993, Boehm, 1991, Hoermann *et al.*, 2012, Keil *et al.*, 2002, Schmidt *et al.*, 2001, Smith *et al.*, 2006)	(Kakkar *et al.*, 2013)
R 18	Poor team requirement analysis	Poor or lack of requirement definition and testing. This includes business, technical, and design requirements.	Rephrased from the initial risk of 'Poor understanding of end users' needs'	(Addison & Vallabh, 2002, Baccarini *et al.*, 2004, Hoermann *et al.*, 2012, Keil *et al.*, 2002, Liu *et al.*, 2010, Marnewick & Labuschagne, 2009, Schmidt *et al.*, 2001, Smith *et al.*, 2006, Tesch *et al.*, 2007)	(Dey & Häkkilä, 2008, Flora *et al.*, 2014a, Hutahaean *et al.*, 2020, Kakkar *et al.*, 2013)
R 19	Size of the release	Releases that are too big and have a lot of code changes to be tested and opportunities for bugs to be introduced.	Retained as is	(Barki *et al.*, 1993)	(Jha, 2007)
R 20	Poor quality control	Lack of team ownership to pick up on inconsistencies across devices and throughout the app e.g. search fields across the	Rephrased description	(Hoermann *et al.*, 2012, Liu *et al.*, 2010, Tesch *et al.*, 2007)	(Ahmad *et al.*, 2018, Flora *et al.*, 2014a, Kakkar *et al.*, 2013,

		app or UI inconsistencies on different screen sizes or general functional performance.			Wasserman, 2010)
R 21	Excessive test coverage	Misalignment of test effort with agreed upon minimally acceptable quality standard or minimum viable testing (MVT).	Rephrased description		(Ahmad *et al.*, 2018, Flora *et al.*, 2014b, Jha, 2007, Kakkar *et al.*, 2013, Wasserman, 2010)
R 22	Poor task management	Assignment/coordination of tasks/bugs are not done effectively and confuses of what the highest priority is, and whose priority it is.	Rephrased from the initial risk of work assignment	(Addison & Vallabh, 2002, Liu *et al.*, 2010, Matavire *et al.*, 2010)	(Jha, 2007)
R 23	Poor user experience	Negative experience with the product because of poor product understanding, or poor customer support.	Rephrased to also include customer support.	(Addison & Vallabh, 2002, Boehm, 1991)	(Dey & Häkkilä, 2008, Flora *et al.*, 2014a, Hutahaean *et al.*, 2020, Ketola, 2002, Sahd & Rudman, 2016)
R 24	Lack of innovation	Not releasing unique/original features and mostly mimicking what other payment apps are doing.	Retained as is	(Baccarini *et al.*, 2004, Hoermann *et al.*, 2012)	
R 25	Over innovation	Too much change too quickly can be confusing to users.	Split from 'Lack of innovation'.	(Liu *et al.*, 2010, Marnewick & Labuschagne,	

				2009, Schmidt *et al.*, 2001)	
R 26	Inadequate platforms and tools used	The platforms or tools being used are causing more issues rather than assisting the team in executing their tasks.	Retained as is		(Dehlinger & Dixon, 2011, Flora *et al.*, 2014a, Jha, 2007, Kakkar *et al.*, 2013)
R 27	Third-party dependencies	Aligning our timelines with the timelines of external parties and/or their architecture.	Rephrased to also include system architecture	(Yang *et al.*, 2014)	(Dehlinger & Dixon, 2011, Wasserman, 2010)
R 28	Poor marketing exposure and targeting	Lack of marketing and/ or poor market targeting.	Rephrased to also include targeting the appropriate market		(Flora *et al.*, 2014a)
R 29	Poor team skills and capabilities	Lack of skills and capabilities to perform tasks associated with their job role.	Retained as is	(Hijazi *et al.*, 2014, Kanjanda & Tuan, 2020, Vidgen & Wang, 2009)	(Flora *et al.*, 2014a, Jha, 2007)
R 30	Inadequate task estimation	Overestimating fewer complex tasks or underestimating complex tasks.	Retained as is		(Hutahaean *et al.*, 2020)
R 31	Work interruptions and context switching	Frequent work interruptions that require context switching.	Retained as is	(Matavire *et al.*, 2010)	

R 32	Timing and frequency of demos to stakeholders	Involve important stakeholders early on and frequently to address bugs or updates to the release.	Rephrased to include frequency.	(Addison & Vallabh, 2002, Baccarini *et al.*, 2004, Keil *et al.*, 2002, Schmidt *et al.*, 2001, Smith *et al.*, 2006)	(Dar *et al.*, 2018, Kakkar *et al.*, 2013)
R 33	Insufficient test coverage on multiple devices used by the target market	Product is not effectively supported across a wide variety of devices used by the target audience.	Rephrased 'Multiple devices in the market' to focus more on targeting specific devices used by the target market		(Ahmad *et al.*, 2018, Dehlinger & Dixon, 2011, Flora *et al.*, 2014a, Kakkar *et al.*, 2013, König-Ries, 2009, Sahd & Rudman, 2016, Wasserman, 2010)
R 34	Poor quality and observability of data/analytics to understand user behaviour	Lack of or unobservable data for user insights.	Rephrased to include observability of data/analytics.		(Dehlinger & Dixon, 2011, Flora *et al.*, 2014a, Sahd & Rudman, 2016)

Based on table 4.4 risks that were not identified by the study on MAD projects, and only highlighted in studies focusing on traditional software development projects include:

1. Poor timing of the technology;
2. Powerful stakeholders that are biased;
3. Lack of innovation;
4. Over innovation; and
5. Work interruptions and context switching.

Risks that were not mentioned by literature on traditional software development projects, and only referenced in MAD project literature include:

1. Large amount technical debt;
2. Excessive test coverage;
3. Inadequate platforms and tools used;
4. Poor marketing exposure and targeting;
5. Inadequate task estimation;
6. Insufficient test coverage on multiple devices used by target market; and
7. Poor quality and observability of data/analytics to understand user behaviour.

In the subsequent Idea, structuring phase participants will be presented with the 34 risks and asked to vote on whether a significant contextual relationship exists doing a pair-to-pair comparison. This exercise was done using Interpretive Structural Modelling (ISM) software to structure and examine the relationships between all the identified risks.

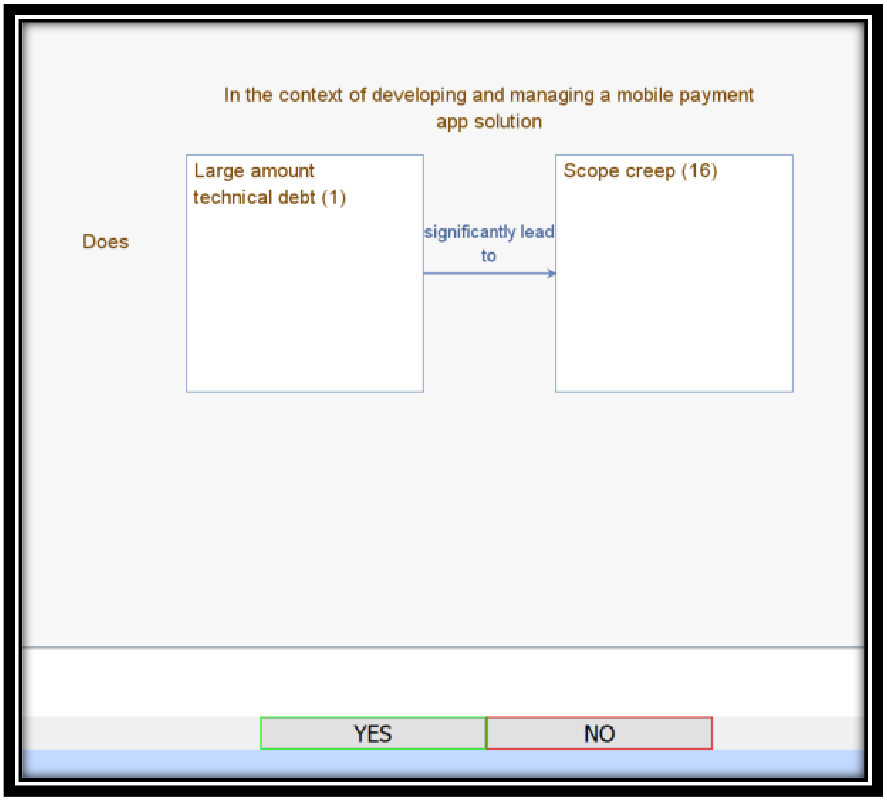
4.4 Idea structuring – ISM model

The purpose of this phase is to structure the relationship between dominant risks using Interpretive Structural Modelling (ISM). ISM transforms poorly defined perceptions about a problem situation into a model that facilitates a better understanding of a complex problem (Warfield & Cárdenas, 1994). The fundamental concepts of the ISM approach include the "element set" that was produced in the previous phase and the "contextual relationships" that exist between the elements - in this case, the risks (Iyer & Sagheer, 2010). The type of contextual relationship chosen for this research is defined as *significantly lead to*. The contextual question that will guide this discussion is structured as follow:

> In the context of developing and managing a mobile payment app solution, does risk X significantly lead to risk Y

This is shown in Figure 4.1, an image extracted from the ISM software during the workshop. Due to other commitments and responsibilities the group discussion was executed throughout four online video calls (using Microsoft Teams) where participants were presented with the contextual question to guide discussions on the contextual relationships that exist between the identified dominant risks/elements that came from the previous phase. The structuring was done through a verbal voting process where each participant voted either 'yes' or 'no' to define a specific relationship. Where participants were not in agreement, the minority voters were asked to clarify their reasoning. After their elaboration, the team was asked to vote again and the majority vote (at least 6 of 8) was selected.

Figure 4. 1: Contextual question posed to the participants during Idea Structuring.

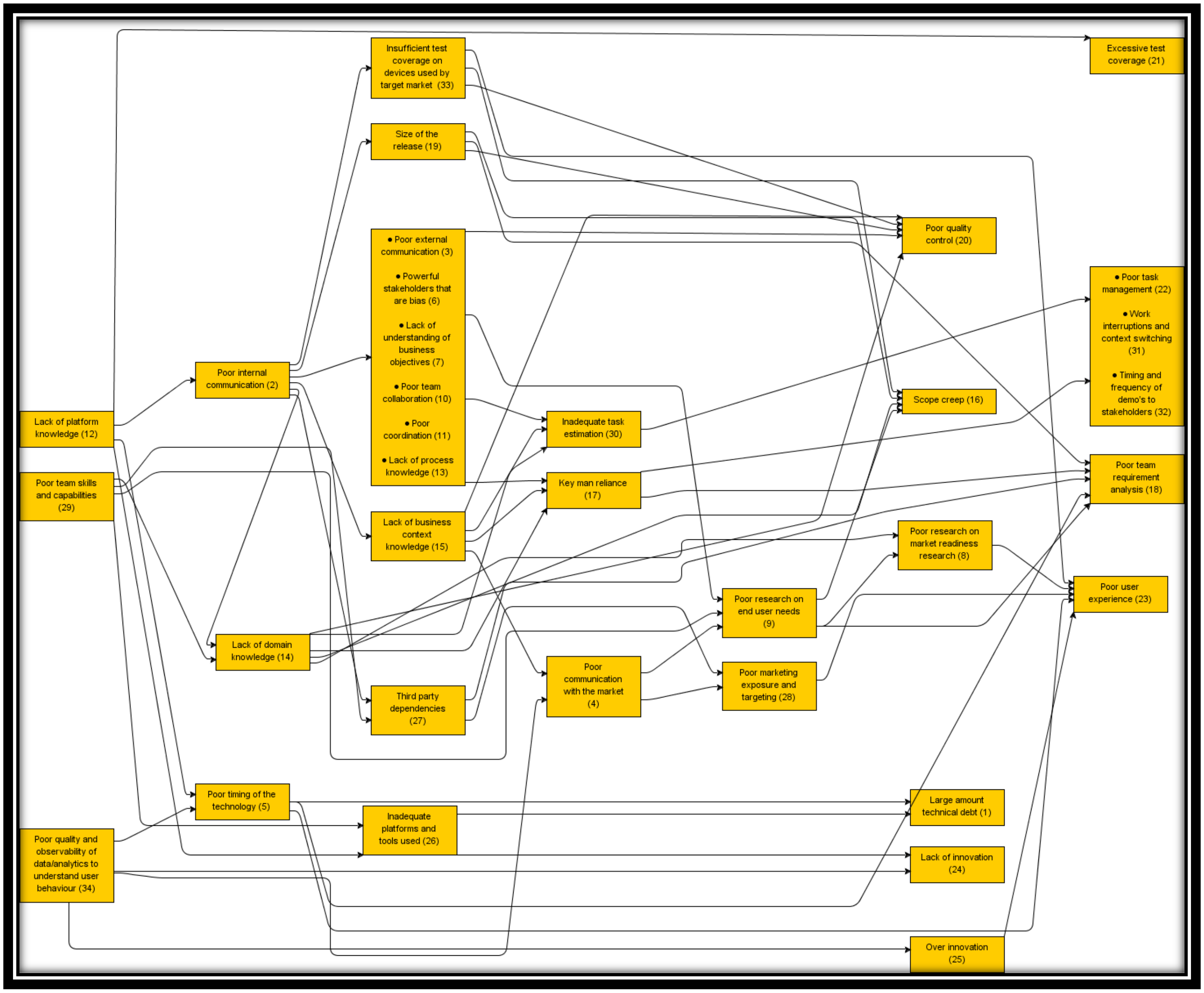


A pair-wise comparison of all the MAD project risks was conducted in this way. 'Yes' was reflected by assigning 1, while 'no' was reflected by 0. Figure 4.2 reflects the pair-wise comparison matrix. The output of this phase was a risk diagraph portraying the risk relationships and highlighting the dominant risk drivers that are reflected in figure 4.3. Upon completion of the idea structuring process, the model was presented to all the participants for final review to confirm that they agree with the position and influence of each risk. There were no objections, and the model remained the same which will be discussed in more detail in the final stage of Interpretation.

Figure 4. 2: Pair-wise comparison matrix

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1
0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	1	1	1	0	1	1	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0
0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0
0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Figure 4. 3: ISM graph of MAD risks



4.5 Interpretation of the ISM model

All the arrows in figure 4.3 illustrate a 'significantly leads to' contextual relationship between the risks identified in the earlier phases of idea generation and clarification. Risks that are at the far left of the model, namely 'Lack of platform knowledge', 'Poor team skills and capabilities', and 'Poor quality and observability of data/analytics to understand user behaviour', are not created by other risks and can be considered as the core risks that significantly lead to subsequent risks. The ISM model is divided into six hierarchical levels, where levels 1 and 2 will be discussed further in this section as they are the risks that mostly lead to subsequent risks.

4.5.1 Level 1 risks

4.5.1.1 Lack of platform knowledge

The participants define this risk as lack of understanding of the platforms used in building the product. In taking a more holistic view and considering a variety of stakeholders the platforms used are at times specific to a certain stakeholder. For example, developers (problem-solvers) will use platforms to compile their source code, while testers (problem solvers) use automation platforms to build and run automated tests. Product managers (problem-owners) on the other hand, use platforms to define and prioritize the team roadmap. However, certain platforms are used by most participants. These include task management platforms, communication platforms, and document storing platforms. It is therefore important to know the platforms used by specific stakeholders as well as of the platforms used across different stakeholders. Lack of platform knowledge significantly leads to 'Poor internal communication', 'Poor timing of the technology', 'Chosen platforms and tools used'

4.5.1.2 Poor team skills and capabilities

This risk was defined as a lack of skills and capabilities to perform tasks associated with their job role. Due to the participants presenting a wide variety of stakeholder roles, this risk incorporates different types of skills and capabilities. For example, developers and testers (problem-solvers) require adequate technical skills to understand the source code, whereas graphic designers (problem-solvers) require creativity and user interface design skills. Problem owners, such as development team leads/managers are concerned about the system performance and require skills and capabilities to understand the larger environment and how components interact with each other. Lastly, decision-makers, such as product managers focus on stakeholder relationships and business strategy that requires skills such as good communication and relationship building.

4.5.1.3 Poor quality and observability of data/analytics to understand user behaviour

This risk was defined as the lack of or unobservable data that can be used to gain valuable user insights. The team collects data from a variety of sources including, user analytics Software Development Kits (SDK) to observe interaction with the mobile application. Transactional data is collected and stored in a transaction database, while user reviews and rating information can be collected on the respective application stores and social media platforms. However, the participants agreed that this data is either not easily accessible or the reliability of the data is questionable. This risk significantly leads to 'Poor timing of the technology', 'Lack of innovation', 'Over innovation', and 'Poor communication with the market'.

4.5.2 Level 2 risks

4.5.2.1 Poor internal communication

This risk was defined as not communicating frequently and effectively within and across teams. The team agreed that since the Covid pandemic where they all work from home, communication was not as frequent when compared to working in the same location. All communication is done either through email or Microsoft Teams chat and call functionality. The team typically chats with individuals throughout the day and has a cross-team check-in at the end of the workday. They highlighted that individual/private chats prevent the transparent flow of information and usually result in important stakeholders not having the latest information at hand. Furthermore, their check-in at the end of the day is usually too late to take immediate action where required. 'Poor internal communication' significantly leads to 10 subsequent risks, such as "Insufficient test coverage on devices used by target market', 'Size of the release', 'Poor external communication', and 'Lack of business context knowledge'. The full list of risks is depicted in figure 4.3.

4.5.2.2 Lack of domain knowledge

This risk is defined as a lack of technical knowledge on how the product interacts with the larger system. Domains highlighted by the participants include the back-end API's and how they interact with third party API's or the actual mobile application, the design system and how that is used to incorporate different iconography, colour, and layout within the mobile application, and the payment domain where transactions are processed with third-party service providers and users are notified about their payment status. The lack of understanding on how the product interacts with the larger system significantly leads to 'Poor quality control', 'Poor task estimation', 'Key man reliance', 'Scope creep', and 'Poor research on market readiness'.

4.5.2.3 Poor timing of the technology

This risk occurs when new features fail as a result of incorporating technology that is too new and not properly supported by external platforms or hardware. An example given was a parking ticket payment solution that was released at large malls across South Africa. The business value behind this solution was that more individuals would use the mobile payment application to pay for their parking tickets. However, multiple end-users complained that they had no internet connectivity in the basements of malls and had to drive to a spot where they had connectivity to process the payment. The poor timing of the technology significantly leads to 'A large amount of technical debt', 'Poor team requirement analyses', and 'Bad user experience'.

Risk at the far right of the model, namely 'Excessive test coverage', 'Poor task management', 'Work interruptions', 'Timing of demos to stakeholders', and 'Bad user experience', do not result in subsequent risks, and are considered to be less important. The idea of this model is to focus on risks that significantly lead to other risks, rather than risks that do not significantly lead to others.

4.6 Secondary research finding/literature review reflection

This section will reflect on how the findings from the IM process relate to the literature discussed in chapter 2 and summarized in table 4.4 of this report.

A wide variety of studies acknowledged the subjective nature of risks and argued that risks perceptions differ amongst individuals based on their culture or stakeholder role (Boehm, 1988, de Camprieu *et al.*, 2007, Kanjanda & Tuan, 2020, Mursu *et al.*, 2003, Schmidt *et al.*, 2001). This raises the concern of the potential bias involved or scope limitation inherent within the studies reviewed in this section. Furthermore, when identifying participants it is important to consider whether they are truly representative and knowledgeable about the situation at hand, and not merely strive towards a specific 'sample size' (Ntshangase & Tuan, 2019). For this study, eight participants were identified in line with the stakeholder roles as defined by Achterkamp & Vos (2007). The participants were representative of all five stakeholder roles. At times, participants were classified under more than one role.

The remainder of this section will compare the risks highlighted through the IM process with frequently cited risks in literature (as presented in table 4.3) on traditional software development projects and MAD projects.

Risk Management is a term introduced to describe measures and activities implemented to manage these negative risks (Addison & Vallabh, 2002) and it mainly focuses on finding answers to three questions (Kanjanda & Tuan, 2020):

1. What risks are we are exposed to in a particular environment?
2. Of these risks, which ones are the right risks to manage?
3. What measures can we take to proactively manage the right risks?

Aligning this definition of risk management with the research objectives described in chapter 1, question 3 falls outside the scope of this study and questions 1 and 2 will be addressed.

To answer question 1 (aligned with research objective 1), a total of 34 risks were identified during the idea clarification phase and are presented in table 4.4. The table lists the risks with their descriptions and links them to references in either traditional software development literature or MAD project literature. It is important to note that this is not an exhaustive comparison as the research findings were only compared with the top risks identified from the literature. Comparing the team's list with the risks in traditional software development research five risks are frequently cited:

1. Poor team requirement analysis (nine references);
2. Poor communication with the market (eight references);
3. Scope creep (eight references);
4. Key man reliance (eight references); and
5. Poor coordination (six references).

Furthermore, when comparing the team's list with research done in MAD projects five risks were frequently cited:

1. Insufficient test coverage on multiple devices used by target market (seven references);
2. Poor team collaboration (six references);
3. Poor user experience (five references);
4. Excessive test coverage (five references); and
5. Poor coordination (five references).

It is interesting to note that when comparing the most frequently cited risks in traditional software development research with MAD project research they do not necessarily align. 'Poor coordination' was the only risk that was frequently cited by both research fields. This risk translates to poor or lack of adequate project planning which is linked to the teams/individual's project management capabilities. Finally, even though security has been mentioned by a wide variety of authors (Dwivedi *et al.*, 2010, He *et al.*, 2015, Mylonas *et al.*, 2013, Shabtai *et al.*, 2010, Theoharidou *et al.*, 2012) and explained in section 2.3 of this report, it was not identified by the participants as a major risk needing to be addressed.

To answer question 2 (aligning with research objectives 2 & 3), participants discussed the contextual relationships that exist between the risks in order to identify those that are the core drivers leading to subsequent risks. The output of these discussions was an ISM risk model where important risks are allocated on the far-left side of the model and less important risks are on the far-right side of the model. Risks that are on the left side and can be considered as the most important risks include:

1. Lack of platform knowledge;
2. Poor team skills and capabilities; and
3. Poor quality and observability of data/analytics to understand user behaviour.

Although these three risks are highlighted in some research papers, they are not necessarily frequently cited. When comparing 'Lack of platform knowledge' with the literature in table 4.4 it is cited by three authors researching traditional software development, and two researching MAD projects and environments. 'Poor team skills and capabilities' is cited by three authors in the traditional software development field, and two MAD project research papers. Lastly, 'Poor quality and observability of data/analytics to understand user behaviour' is not cited by any authors exploring traditional software development and only three MAD research papers. Although these three risks are not often cited in existing literature they can be deemed as important within the unique context of MAD projects and environments. Therefore, these three risks need to be the main focus for the organisations when addressing risk management within their environments.

4.7 Conclusion

The purpose of this chapter was to present the results from the IM process, analyse the ISM model that was developed during online video calls, and lastly, compare it with the literature discussed in chapter 2 and referenced in table 4.4 of this report. A total of 34 risks were analysed and the results showed that three risks need to be addressed for each MAD release cycle to realise project success. These risks were highlighted on the left side of the model and stretched across levels 1 and 2 of the hierarchy. The following chapter will reflect on the research problem statement, research questions and objectives and conclude with research limitations, contributions to existing knowledge, and recommendations for future research.

CHAPTER 5: Conclusion and recommendations

This final chapter summarizes and concludes the research undertaken. The study adopted a soft systems approach using Interactive management (IM) to explore core risks that negatively impact MAD project outcomes. Furthermore, it will compare the finding with the problem statement and research objectives. This will be followed by a discussion around the limitations of this research, its contribution to existing knowledge, and will conclude with recommendations for future research.

5.1 Reflection on the problem statement and research objectives defined by the study

The aim of this research was to develop an understanding of the most common risks encountered during MAD projects, and identify the interrelationships that exist between these risks to address the problem statement presented in chapter 1.

Findings showed that the majority of participants agreed that MAD projects generally experience high failure rates, and numerous risks exist that are unique to MAD environments and negatively impact project outcomes. However, there was at first no consensus amongst the participants on which risks have the biggest impact on project outcomes. This is in line with research from numerous authors who state that risks are subjective and perceived differently amongst individuals. This is usually affected by their culture or stakeholder roles they fulfil (Addison & Vallabh, 2002, Boehm, 1988, de Camprieu *et al.*, 2007, Mursu *et al.*, 2003, Schmidt *et al.*, 2001). Participants occupied various stakeholder roles as defined by Achterkamp & Vos (2007) and were internal and external to the organisation. Extending on the problem statement and research questions stated in chapter 1, this study defined three research objectives to be achieved:

5.1.1 Objective 1: Identify unique risks in MAD projects that typically affect project success.

To address the first objectives eight participants (occupying different stakeholder roles) were asked to list the top six risks they perceive as having a significant impact on MAD project outcomes. This was implemented through an online survey. Based on the output of the survey a list of 28 risks were compiled. This was implemented through the idea generation phase of IM. Thereafter, in the idea clarification phase participants attended online video calls where the description of each risk was explored and agreed upon. Some risks were deleted from the list while other risks were split into separate elements. The final output of this phase was a list of 34 risks.

Although some risks identified were highlighted by studies that focused on traditional software development projects, there were unique risks that were identified by participants and frequently cited in previous research which focused on MAD projects and the environment. These risks are referenced in table 4.4 and include:

1. Insufficient test coverage on multiple devices used by target market;
2. Poor team collaboration;
3. Poor user experience;
4. Excessive test coverage; and
5. Poor coordination.

Furthermore, five risks were identified by the team that are often referenced in research surrounding traditional software development projects and summarized in table 4.4 include:

1. Poor team requirement analysis;
2. Poor communication with the market;
3. Scope creep;
4. Key man reliance; and
5. Poor coordination.

It is interesting to note that although security was highlighted by a wide variety of papers (Dwivedi *et al.*, 2010, Mylonas *et al.*, 2013, Shabtai *et al.*, 2010, Theoharidou *et al.*, 2012), it was not identified amongst the participants as an important risk that negatively impacted MAD project outcomes.

5.1.2 Objective 2: Understand the relationships that exist between these risk factors.

To address the second objective ISM software was used during online video calls where all participants discussed and voted for significant risks based on a pair-to-pair comparison between all 34 risks. This was done through the Idea structuring phase of the IM process. Where there was no consensus on whether a significant relationship existed between the two risks, the participants with the minority vote explained why they do not agree with the majority. The group was then asked to vote again, and the significance of the relationship was confirmed by a majority vote.

The output of this phase was an ISM model depicting the relationships between all the risks. The model consists of six risk levels of which levels 1 and 2 include risks that have the most impact on subsequent risks, and levels 5 and 6 have little to no impact on other risks. The following conclusions can be drawn from the ISM model as portrayed by figure 4.3 in the previous chapter:

1. Levels 1 and 2 make up around 18% (6) of the entire model and significantly lead to the remaining 82% (28) of the risks. These six risks are therefore identified as the most important risks that should be prioritised and addressed to mitigate or decrease the impact on subsequent risks.

2. There are 10 risks on the right side of the model that do not result in any other risks. These elements make up 29% of the model and are deemed as less important when addressing risk management in MAD projects and environments.
3. Level 3 and level 6 highlighted feedback loops amongst certain risks. Feedback loops indicate risks that are bound and can give guidance on how organisations should intervene to control the system behaviour amongst these risks (Jackson, 2016). Furthermore, these feedback loops indicate that when managers solve one of the risks in the loop they can decrease the impact on other elements in the loop (Nthunya et al., 2017).

5.1.3 Objective 3: Describe the root causes or risk drivers unique to MAD projects.

To address the third objective, the risks included in level 1 are highlighted to identify the core risk drivers that negatively impact MAD project outcomes:

5.1.3.1 Lack of platform knowledge

This risk was defined as the lack of understanding of the platforms used in building the product. It is important to note that this risk encapsulates a range of different platforms that have a specific purpose. Examples of these platforms include, but are not limited to, front-end design platforms, development platforms, testing platforms, work assignment platforms. This risk significantly leads to 'Poor internal communication', 'Poor timing of the technology', and 'Lack of innovation'. 'Lack of platform knowledge' is a common risk that is frequently cited in traditional software development and MAD research.

5.1.3.2 Poor team skills and capabilities

This risk was defined as the lack of skills and capabilities required to perform tasks associated with their job role. Similar to the previous risk, this element encapsulates a wide variety of skills and capabilities as a result of including stakeholders from various roles. This risk significantly leads to 'Thirdparty dependencies', 'Poor research on end-user needs', 'Lack of domain knowledge', and 'Inadequate platform and tools used'. Poor team skills and capabilities' are more often referenced in studies surrounding traditional software development. Although this risk was cited in a MAD study done by Flora *et al.* (2014a), it mainly focussed on the skills of the developers and not necessarily those of the different team members as it relates to their specific roles.

5.1.3.3 Poor quality and observability of data/analytics to understand user behaviour

This risk was defined as the lack of or unobservable data for user insights. According to the standards for Ergonomics of human-system interaction (ISO, 2010), feedback from end-users during operational use identifies long-term issues and provides input for future design. Therefore, the lack of this type of information could lead to organisations being unaware of long-term issues and what updates or fixes are required. This risk significantly leads to 'Poor timing of the technology', 'Lack of innovation', 'Over innovation', and 'Poor communication with the market'. 'Poor quality and observability of data/analytics to understand user behaviour' was more often references in studies focussed on MAD projects, and not often highlighted in research on traditional software development.

5.2 Limitations of this study

The scope of this research was limited to focusing only on risks encountered within the MAD project implementation environments, and not generic risks shared with other types of software development projects. Therefore, the following limitations will apply to the study:

1. The focus on MAD projects was limited as stakeholders from other types of software development projects might have different views that could also be relevant to MAD projects.
2. The number of participants that partook in the IM intervention was limited to eight which restricted the diversity and number of issues that were explored.
3. Since the participants involved were limited, a broad generalisation could not be drawn from the findings, but rather great insight specific to MAD projects.
4. The risks and the relationships identified in this study will be open-ended and not exhaustive as it was based on the experience of the participants involved.
5. Although this study acknowledged that risks perception differs amongst participants because of their culture and stakeholder roles, the research did not explore the cultural aspects but was limited to stakeholder roles.
6. Participants were asked to identify risks that negatively impact MAD project outcomes. They did not elaborate on what the negative impacts are.
7. This study was limited to identifying risks and highlighting the important risks. It did not explore the measures that can be taken to proactively manage these risks.
8. This study was limited to a specific type of contextual relationship ('significantly leads to') and did not consider other types of relationships, such as 'does the existence of risk A decrease the probability of risk B'.

5.3 Contribution to existing knowledge

The research contributes to the following:

1. Risks that are identified and prioritised as dominant risks can be compared to the lists from existing studies that aimed to highlight unique risks in MAD projects.
2. By understanding the inter-relationships between risks, a few root causes/risk drivers can be highlighted which should receive more attention throughout the project.
3. By adopting a systemic approach, it will help to reveal context-specific issues which may not be available in the existing literature.
4. The collaborative learning nature of the IM approach adds to research on the sustainability of complex MAD projects implemented in pluralist and coercive environments.

5.4 Recommendations for future research

The findings from this study can be further improved by:

1. Expanding the scope of research to include more stakeholders;
2. Exploring risk response strategies to proactively manage the level 1 risks;
3. Considering the cultural aspect that influences risks perceptions in MAD projects;
4. Using analytical frameworks as the risk management approach to categorize the risks by their source.

5.5 Conclusion

This research argued that MAD projects and environments have unique aspects that distinguish it from traditional software development projects. Furthermore, MAD projects and environments are multifaceted and complex by nature. Existing literature provides generic lists of potential risks that could exist within a complex environment. However, it is argued that previous research adopted a reductionist view that did not consider the interrelationships between risks. This research, therefore, aimed to understand the core risk drivers within MAD projects and environments by considering the contextual relationships amongst identified risks.

The research adopted soft systems approach using an Interactive Management (IM) methodology. This approach advocates and emphasizes learning amongst the participants. However, these learnings cannot be generalized and are unique to the problem situation at hand. An Interpretive structural modelling (ISM) tool was used to facilitate careful and logical thinking around the complex issue of the MAD project and environmental risks.

The findings revealed that three risks should be considered when addressing risk management within this specific MAD project and environment context. These include 1) Lack of platform knowledge; 2) Poor team skills and capabilities; and 3) Poor quality and observability of data/analytics to understand user behaviour.

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Addenda

Addendum A: Ethics approval

Application for Approval of Ethics in Research (EiR) Projects
Faculty of Engineering and the Built Environment, University of Cape Town

ETHICS APPLICATION FORM

Please Note:
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the **EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant		Ashlea du Plessis
Department		Construction Economics and Management
Preferred email address of applicant:		ashleaduplessis@gmail.com
If Student	Your Degree: e.g., MSc, PhD, etc.	MSc Project Management
	Credit Value of Research: e.g., 60/120/180/360 etc.	60 Credits
	Name of Supervisor (if supervised):	Dr. Nien-Tsu Tuan
If this is a researchcontract, indicate the source of funding/sponsorship		
Project Title		A systemic exploration of risks in mobile application development projects

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

APPLICATION BY	Full name	Signature	Date
Principal Researcher/ Student/External applicant	Ashlea du Plessis		10/03/2021
SUPPORTED BY	Full name	Signature	Date
Supervisor (where applicable)	Dr. Nien-Tsu Tuan		10 Mar 2021

APPROVED BY	Full name	Signature	Date
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section 1; and for all Undergraduate research (Including Honours).	Dr. Frank K. Ametefe		06 May, 2021
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the questions in Section 1.	Dr. Frank K. Ametefe		06 May, 2021

Page **1** of **1**

Addendum B: Participant consent form template

Information sheet and consent form

Introduction

My name is Ashlea du Plessis and I am conducting research towards a master's degree in project management. I am investigating risks associated with mobile application development (MAD) projects and would like to invite you to participate in the project.

About the project

The project is aimed at investigating the risks within mobile application development (MAD) projects and the causal relationships that exist between them. This is to establish what the main risk drivers/root causes are within these types of projects and environments.

Participation is voluntary

Please understand that you are not obligated and do not have to participate in this project. Your participation is entirely voluntary. The choice to participate is yours alone. If you choose not to participate, there will be no negative consequence. If you choose to participate, but wish to withdraw at any time, you will be free to do so without negative consequence. However, I would be grateful if you would assist me by allowing me to interview you.

Expectations from participations

I will only ask you a few questions regarding what the top risks are and what the relationships are between them. There is no financial obligation from the project or you as the participant. Therefore, there is no payment/reimbursement available. With your permission, I would record this interview however you do not agree that is still acceptable. I also need your consent to refer to this recording and any notes I may have taken for academic purposes including my project, academic conferences and possibly journal publications.

Benefits to participants

No indirect or indirect harm

Risk of harm to participants

No foreseen or unforeseen risks

Sharing and use of data

Data generated from the interview will be synthesised and used to answer the research questions set for this master's project, presented in conferences and may be published in journals.

Anonymity and confidentiality

Identity encoded but standing conveyed (it matters who you are interviewing)

By signing the consent form, you agree to the terms stipulated in this consent sheet regarding the interview. If you are not comfortable with the terms, please make a note on the form.

Interviewee name:

Interviewee's signature:

Date:

Additional comments:

Participation Information Sheet

1. Research title

A systemic exploration of risks in mobile application development projects and environments.

2. What is the purpose of this research?

You are being invited to participate in a qualitative study developed by researchers at the University of Cape Town. This research aims to develop an understanding of the most common risks encountered during MAD projects and identifying the interrelationships that exist between these risks. By understanding the relationships between risk, the root causes/main risk drivers can be identified.

3. What will the research involve for me?

Data collection will involve multiple stages. **At first,** we will **receive a questionnaire** to describe your involvement in MAD projects and to list the top 6 most dominant risks that lead to project failure. **Once submitted, you will be contacted via email** with details of the next stage. In the next stages, you will be part of an **online group discussions** to refine and agree on the top 6 risks. **Once the list is refined**, you will receive a **second online meeting invite.** In the **final session** a **group discussion** will be had to determine the relationships between the risks and what the main drivers/root causes are that lead to MAD project failure.

The **initial questionnaire** will take you up to **10 minutes** to complete. The **second stage**, the group discussion, will take **60 min**. The **final group discussion** session will not take longer than **180 min**.

4. What are the possible benefits of taking part?

Any insights we can gain from your participation will be extremely useful in explaining the relationships between dominant MAD project risks, helping us to better understand what the root causes are that lead to MAD project failure. We will conduct an online lucky draw to show our gratitude for your participation and four winners will be selected, each winning a voucher worth R500. You will be entitled the right to join this draw if you complete all stages of the survey.

5. Am I eligible to participate in this survey?

This survey is only for employees of Zapper who are involved in the delivery of MAD projects.

6. Do I have to take part and can I withdraw my response from the research?

Participating in this study is entirely voluntary. You are free to not participate in this research at all. If you have successfully signed up to the survey but afterwards decide not to participate in the formal survey, or if you have already started with the formal survey but later on do not want to continue anymore regardless of the reason, you have the right to exit at any point of the survey and we will delete your response from the dataset. There will be no consequences for failing to complete the survey. This data collection and research work is totally independent from the university's employment/ assessment. Once you have submitted your final feedback in the last group discussion, it is not possible to withdraw your data.

7. Will my taking part in the research be kept confidential and how will the data be processed?

Please bear in mind that no personally identifiable information will be required throughout the entire data collection. You will only be asked to leave your email address to sign up, allowing us to invite you for a follow-up discussion and be registered for the raffle game. If you are willing to reveal your email address, this information will be irrevocably deleted after the entire data collection is finished. This data collection and research work is for our academic use only. Publication of research outputs or potential sharing of data with other research institutes will only take place after the thorough anonymisation and will not disclose any personally identifiable information.

8. Ethical approval

The research has been reviewed and approved by the University Research Ethics Committee of UCT, with the ethics reference number and permission has been obtained to circulate this survey.

9. What if I feel discomfort while taking part in this research?

We understand this is a difficult time which can be very distressing. If you feel particularly anxious or find it distressing to consider changes that the COVID situation has brought about to you, please do not hesitate to quit this survey.

10. What if I have any questions?

We very much appreciate your valuable input, and we hope you stay well. This statement has been developed to protect people who agree to take part in research studies. If you have a complaint/concern, please contact Dr. Nien-Tsu Tuan (the student's supervisor) at nien-tsu.tuan@uct.ac.za. If you require more information about this research or have any questions about the survey, please feel free to contact the research student at DPLASH002@uct.ac.za

Consent form for recording of interview – to accompany information sheet given to participant

Title of project: A systemic exploration of risks in mobile application development projects and environments.

Name of interviewer: Ashlea du Plessis

Title of degree: MSc Project Management

University of Cape Town

I ………………………………………………………………………………………………, confirm the following:

1.	I have read the information sheet provided by the researcher and thus understand the projects aims and objectives.	
2.	I am participating in this project voluntarily and understand that I may withdraw from the interview at any time if I so do wish.	
3.	I acknowledge and understand that confidentiality will be maintained.	
4.	I have been asked permission to record this interview and have given my permission.	
5.	I understand that this data is accessible to other researchers only if they honour the confidentiality agreement.	

Addendum C: Research questionnaire template

Mobile App Development (MAD) Project Risks Survey

This questionnaire is the first phase of an exploratory study aimed at understanding the unique risks associated with Mobile Application Development (MAD) projects.

The output of the first phase it to develop a comprehensive list of what participants perceive as important risks to be considered in MAD projects.

Subsequent phases will follow an Interactive Management (IM) approach that involves group discussions aimed at understanding the causal relationships that exist between the risks.

The final output of the(se) workshop(s) will be to develop a team understanding of the root causes/main drivers that lead to MAD project failure.

The questionnaire does not have any personal questions that might reveal the identities of study participants.

The dissertation will be archived in the University of Cape Town library.

Results from the study may be published as a research paper.

Section 1 of this survey will ask questions mainly around your role within MAD projects and environments.

Section 2 will focus on listing risks that you feel have a significant impact on project outcomes.

---

* Required

Stakeholder Role Definition

1. How many years have you been working within MAD projects and environments? *
2. In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

3. How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you. *

Check all that apply.

☐ Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered

☐ You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.

☐

☐ You are an end-user and do not actively work on the development projects

☐ Your focus is on team performance

Your role mainly involves defining the scope and aligning it with business strategy

MAD Project Risks

4. Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

Addendum D: Survey responses

Mobile App Development (MAD) Project Risks Survey

This questionnaire is the first phase of an exploratory study aimed at understanding the

associated with Mobile Application Development (MAD)

The output of the first phase it to develop a comprehensive list of what participants perceive as risks to be considered in MAD

Subsequent phases will follow an Interactive Management (IM) approach that involves group aimed at understanding the causal relationships that exist between the

The final output of the(se) workshop(s) will be to develop a team understanding of the root drivers that lead to MAD project

The questionnaire does not have any personal questions that might reveal the identities participant

The dissertation will be archived in the University of Cape Town library.

Results from the study may be published as a research paper.

Section 1 of this survey will ask questions mainly around your role within MAD projects and

Section 2 will focus on listing risks that you feel have a significant impact on project

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you.*

- [x] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
- [ ] You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.
- [ ] You are an end-user and do not actively work on the development projects
- [ ] Your focus is on team performance
- [ ] Your role mainly involves defining the scope and aligning it with business strategy

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

less than one

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

Estimating and implementing dev work

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

technical debt, poor communication, miss alignment of technical and business objectives, unknown time sinks, team asymmetry, domain knowledge loss potential

Mobile App Development (MAD) Project Risks Survey

This questionnaire is the first phase of an exploratory study aimed at understanding the associated with Mobile Application Development (MAD)

The output of the first phase it to develop a comprehensive list of what participants perceive as risks to be considered in MAD

Subsequent phases will follow an Interactive Management (IM) approach that involves group aimed at understanding the causal relationships that exist between

The final output of the(se) workshop(s) will be to develop a team understanding of the root drivers that lead to MAD project

The questionnaire does not have any personal questions that might reveal the identities participant

The dissertation will be archived in the University of Cape Town library.

Results from the study may be published as a research paper.

Section 1 of this survey will ask questions mainly around your role within MAD projects and

Section 2 will focus on listing risks that you feel have a significant impact on project

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to * you.

- [x] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
- [ ] You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.
- [ ] You are an end-user and do not actively work on the development projects
- [ ] Your focus is on team performance
- [ ] Your role mainly involves defining the scope and aligning it with business strategy

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

4

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

Quality assurance and app testing, bug logging and automation

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

1. Scope creep which leads to missed deadlines and ultimately a rushed project that may lead to project failure.
2. Poor communication about deliverables and expected functionality from stakeholders.
3. Key staff being on leave without having someone else to pick up the work, which can lead to delays or open gaps for other issues.
4. Not being in touch with or being unrealistic about the needs of the end user.
5. Releasing too much at once heightens the risk in terms of what can go wrong. I.e. A massive feature with lots of moving parts is much riskier than releasing smaller, better tested bits of the same feature. 6. Poor communication between teams within the organization, which could lead to something being implemented incorrectly and would have to be fixed later on during the latter stages of the SDLC, and in turn does not go through the same level of testing.

Mobile App Development (MAD) Project Risks Survey

This questionnaire is the first phase of an exploratory study aimed at
associated with Mobile Application Development

The output of the first phase it to develop a comprehensive list of what participants
risks to be considered in MAD

Subsequent phases will follow an Interactive Management (IM) approach that
aimed at understanding the causal relationships that exist

The final output of the(se) workshop(s) will be to develop a team understanding of
drivers that lead to MAD

The questionnaire does not have any personal questions that might reveal
participan

The dissertation will be archived in the University of Cape Town library.

Results from the study may be published as a research paper.

Section 1 of this survey will ask questions mainly around your role within MAD

Section 2 will focus on listing risks that you feel have a significant impact on

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

7

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

Overseeing the product development roadmap and project prioritization; representing and providing context around business requirements; consultant to product, marketing and design decisions.

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

Requirements analysis; quality control; test coverage; technical debt; cross-departmental collaboration; responsibility assignment

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you. *

- [ ] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
- [ ] You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.
- [ ] You are an end-user and do not actively work on the development projects
- [ ] Your focus is on team performance
- [x] Your role mainly involves defining the scope and aligning it with business strategy

Google Forms

Mobile App Development (MAD) Project Risks Survey

This questionnaire is the first phase of an exploratory study aimed at understanding the associated with Mobile Application Development (MAD)

The output of the first phase it to develop a comprehensive list of what participants perceive risks to be considered in MAD

Subsequent phases will follow an Interactive Management (IM) approach that involves aimed at understanding the causal relationships that exist between

The final output of the(se) workshop(s) will be to develop a team understanding of the root drivers that lead to MAD project

The questionnaire does not have any personal questions that might reveal the participant

The dissertation will be archived in the University of Cape Town library.

Results from the study may be published as a research paper.

Section 1 of this survey will ask questions mainly around your role within MAD projects and

Section 2 will focus on listing risks that you feel have a significant impact on project

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

4 years

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you. *

- [x] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
- [x] You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.
- [ ] You are an end-user and do not actively work on the development projects
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- [ ] Your role mainly involves defining the scope and aligning it with business strategy

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

Poorly Researched Market & Audience
Poor User Experience
Lack of effective communication within team
Lack Of Originality
Not Choosing A Platform Wisely
Improper Testing

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

Design system interfaces and layouts to accommodate for an effective and comfortable mobile user experience. Report back to product team on findings and design solutions. Create marketing and media content for user education and awareness. Drink lots of coffee.

Google Forms

Mobile App Development (MAD) Project Risks Survey

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Section 2 will focus on listing risks that you feel have a significant impact on

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you.*

- [x] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
- [ ] You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.
- [ ] You are an end-user and do not actively work on the development projects
- [ ] Your focus is on team performance
- [ ] Your role mainly involves defining the scope and aligning it with business strategy

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

9

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

Maintaining and adding to an existing mobile project on android

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

3rd party dependency. Misunderstanding the platform (mobile vs desktop as example). Transparency with the end user and controlling their expectations. Exposure. Timing. Bad developers.

Mobile App Development (MAD) Project Risks Survey

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The output of the first phase it to develop a comprehensive list of what participants perceive as risks to be considered in MAD

Subsequent phases will follow an Interactive Management (IM) approach that involves group aimed at understanding the causal relationships that exist between

The final output of the(se) workshop(s) will be to develop a team understanding of the root drivers that lead to MAD project

The questionnaire does not have any personal questions that might reveal the identities participant

The dissertation will be archived in the University of Cape Town library.

Results from the study may be published as a research paper.

Section 1 of this survey will ask questions mainly around your role within MAD projects and

Section 2 will focus on listing risks that you feel have a significant impact on project

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you.*

- [x] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
- [ ] You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.
- [ ] You are an end-user and do not actively work on the development projects
- [x] Your focus is on team performance
- [x] Your role mainly involves defining the scope and aligning it with business strategy

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

9

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

Design and engineer software solutions for the mobile application

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

1) Over-commitment (i.e. underestimating workload/time required to complete tasks)
2) Loosely defined requirements
3) Single dependencies (team relying on one person for any particular critical item in project delivery) 4) Context switching (having to switch between unrelated tasks instead of maintaining focus on completing tasks related to main project)

5) Demonstrations of feature implementations to stakeholders at late stage of

development. 6) Scope creep

Mobile App Development (MAD) Project Risks

S...

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Section 2 will focus on listing risks that you feel have a significant impact on

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you.*

- [ ] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
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- [ ] Your focus is on team performance
- [x] Your role mainly involves defining the scope and aligning it with business strategy

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

2

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

Defining the roadmap, design and functional requirements

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

I think all general risk factors associated with software development but I would also suggest these: I am not sure these are official factors, but I would suggest: 1. Unavailability of data to understand user behaviour, 2. Multiple device types and sizes that are released by mobile phone manufacturers

Mobile App Development (MAD) Project Risks Survey

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Subsequent phases will follow an Interactive Management (IM) approach that involves aimed at understanding the causal relationships that exist

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Section 1 of this survey will ask questions mainly around your role within MAD projects

Section 2 will focus on listing risks that you feel have a significant impact on

Stakeholder Role Definition

How many years have you been working within MAD projects and environments? *

none

In a sentence or two, please describe your day-to-day tasks in relation to MAD projects and environment *

none

MAD Project Risks

Project risk in project management is defined as the degree of exposure to negative events that ultimately lead to project failure (Barki et al., 1993). List the 6 most dominant risk factors that you think have a negative impact on MAD project outcomes. *

1. Failure to define the project scope correctly.
2. Failure in proper communication or project and operational environment transparency.
3. Human resources not performing as expected.
4. Insufficient operational structures.
5. Scope creep from management.

How would you define your main role within MAD projects and environments? Choose the option that is most applicable to you.*

- [ ] Your day-to-day tasks involve actively solving problems to ensure projects/software releases are delivered
- [ ] You are affected by the delivery of the project but you have no influence on the actual delivery timeline, scope etc.
- [x] You are an end-user and do not actively work on the development projects
- [ ] Your focus is on team performance
- [ ] Your role mainly involves defining the scope and aligning it with business strategy

Google Forms

Participant

Date ……………………………

Signature of participant ……………………………………………………………….

Name of participant ……………………………………………………………

Organisation of participant……Zapper development……………………………………………………………

Researcher:

Name: ………………………………………………………………………………………………….

Signature: ………………………………………………………………………………………………

Date: ………………………