The development of a fuzzy expert system to aid in the adoption and use of systems development methodologies

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Abstract

A topic of great interest to the field of information system (IS) development is the concept of systems development methodologies (SDMs) and their successful adoption by, and use in, an organisation. Therefore, there exists a need for the developing of software and tools to aid in the adoption and use of SDMs. The focus of this study was to develop a fuzzy expert system that could aid in the adoption and use of SDMs. The study will focus on those factors that influence the adoption and use of SDMs in an organisation, as well as those factors that influence the submitting of rules to a fuzzy expert system to aid organisations in the decision-making process. Due to the fragmented nature of the research available in the field of study, an intensive literature study was undertaken to obtain the available rules. After the rules were identified, the rules were summarised to form the foundation for the development model of the fuzzy expert system. The research design for the study identified the positivism philosophical paradigm as being the most applicable for this study. The research method that was found to be most applicable to the study was the design and creation research method, which was, therefore, employed to conduct the research. The data collection method that was used in the research design was the literature review, which formed the basis of the fuzzy expert system. The fuzzy expert system was developed in two different programming languages, namely FuzzyCLIPS and C#. The fuzzy expert system part of the system was developed in FuzzyCLIPS and the user interface was developed in the procedural language C#.

Keywords: Adoption; diffusion; fuzzy expert system; systems development methodologies (SDMs); use.

Opsomming

Een van die onderwerpe wat van groot belang is op die gebied van inligtingstelsel-ontwikkeling, is stelselontwikkelingmetodologieë en die suksesvolle aanneem en gebruik *daarvan in* 'n organisasie. Daar bestaan dus 'n behoefte aan die ontwikkeling van sagteware en hulpmiddels om te help met die aanneem en gebruik van stelselontwikkeling-metodologieë. Die fokus van hierdie studie was om 'n newelagtige-ekspert-stelsel te ontwikkel wat sou kon help met die aanneem en gebruiksproses van stelselontwikkelingmetodologieë. Hierdie studie sal fokus op die faktore wat 'n invloed sal hê op die aanneem en gebruik van stelselontwikkelingmetodologieë in 'n organisasie en sal die reëls in 'n newelagtige-ekspert-stelsel invoeg om organisasies te help tydens die besluitnemingsproses. Weens die gefragmenteerde aard van die navorsing beskikbaar op hierdie spesifieke gebied is 'n intensiewe literatuurstudie gedoen om die beskikbare reëls te bekom. Ná die reëls geïdentifiseer is, is die reëls opgesom om die grondslag te vorm vir die ontwikkelingsmodel van die newelagtige-ekspert-stelsel. Die navorsing wat vir hierdie studie gedoen is het die positivistiese filosofiese paradigma as die beste metode vir hierdie studie aangedui. Die navorsingsmetode wat vir hierdie studie die geskikste was, is die ontwerp-en-skep-navorsingsmetode en hierdie metode is gebruik om die navorsing te doen. Die data-insamelingsmetode wat gebruik is in die navorsingsontwerp was die literatuurstudie wat die basis van die newelagtige-ekspert-stelsel uitgemaak het. Die newelagtige-ekspert-stelsel is in twee verskillende programmeringstale ontwikkel, naamlik, FuzzyCLIPS en C#. Die newelagtige-ekspert-stelselgedeelte van die stelsel is in FuzzyCLIPS ontwikkel en die gebruikerskoppelvlak is in die prosedurele taal C# ontwikkel. Die newelagtige-ekspert-stelsel kon voorspel of 'n organisasie 'n stelselontwikkelingsmetodologie moet aanneem en gebruik.

Sleutelwoorde: Aanneem; diffusie; newelagtige-ekspert-stelsel; stelselontwikkelings-metodologieë; gebruik.

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IS	information system
IT	information technology
SDM	system development methodology

Chapter 1: Introduction

1.1 Motivation for the study

Of great interest to the field of information system (IS) development is the concept of systems development methodologies (SDMs) and their successful adoption and use in an organisation (Huisman & Iivari, 2006:29-30). Most of the literature on SDMs is fragmented, consisting largely of prescriptive and normative textbooks. Limited scientific studies have been done on the adoption and use of SDMs (Kautz *et al.*, 2004:1-2). Theoretical research in the field of IS development methodologies shows that a methodology should improve effectiveness of development (Vavpotič *et al.*, 2004:1-2). Further investigation has shown that such is not always the case, and that 60% of companies do not use SDMs (Vavpotič *et al.*, 2004:1). The reason for such a high percentage is that SDMs do not fit specific social, cultural, organisational, technological, task-related and environmental characteristics or factors.

As shown by Vavpotič *et al.* (2004:2-3) and Huisman & Iivari (2002a:141-142), the cultural and social factors that impact the development team of the organisation describe the coexistence of such factors and their impact on the developers. For better understanding and the improvement of the adoption and use of an SDM, the measurement of how appropriate the envisaged methodology would be in regards to the development team and the project is required (Vavpotič *et al.*, 2004:2-3). Equally important are those organisational, technological, task-related and environmental factors which have been described by Huisman and Iivari (2002a:137-138) and used with the previously mentioned factors to form an enlarged model of factors that affect the deployment of methodologies. The model or conceptual model describes the relationship

between the factors and interaction with each other to describe or measure the adoption of SDMs.

1.2 Problem statement

Organisations need to select an SDM, based on an examination of the organisational needs. Despite the need for SDMs, there are a large number of methodologies available, so that evaluating and comparing different methodologies is difficult (Fitzgerald, 1994:691-693). This contingency in systems development methodologies makes the selection of the right methodology a challenging task (Fitzgerald, 1994:691-693). Therefore it is important for an organization to select the right SDM to fit the organisation, so as to enable it to fully utilise the methodology. Another crucial factor in successfully adopting and using SDMs is selecting the methodology based on the projects in the IS department.

The research into the adoption and use of SDMs is fragmented and only examines some of the factors that influence the adoption and use of methodologies. The importance of selecting the right methodology is based on those factors that influence its adoption and use, as well as on those that can contribute to both academic and commercial practitioners. The study aims to combine the fragmented research into an artefact that can help practitioners to evaluate whether or not to adopt and use an SDM.

The evaluation of adoption and use factors for an SDM will be aided by the use of a *fuzzy* expert system, which has been developed for the sole purpose of auditing an organisation and for making recommendations based on a knowledge base which is constructed of rules that will be gleaned from a literature study. The rules represent the findings of previous studies on the subject of SDM adoption and successful usage.

1.3 Aim and objectives

The aim of the study is to develop a fuzzy expert system, which will be able to advise an organisation on the adoption and use of an SDM suited to its needs.

The objectives of this research study are:

- to conduct a literature study to establish rules for the adoption and use of an SDM in an organisation;
- to convert the above-mentioned rules into a knowledge base on which the fuzzy expert system can base its decisions; and
- to develop and test the fuzzy expert system.

1.4 Methodology

For the purpose of the study, the philosophical paradigm of positivism, which underlines the scientific approach (Oates, 2006:286), will be followed in researching the different rules in the existing research that are needed to construct the knowledge base for the fuzzy expert system. The rules will be derived from the literature study and will enable the fuzzy expert system to make accurate and informed decisions. The design and creation of the fuzzy expert system will follow a method artefact approach (Oates, 2006:108).

According to Oates (2006:286), positivism, which underlines the scientific method, can be defined as a shared assumption about the nature of the world. The shared worldview is fitting to the research, because no empirical data collections or hypothesis tests characterise a purely scientific method. The literature study will survey the existing

literature about SDMs and their adoption or use, from which it will extract rules that led to the successful adoption or use of the methodologies concerned.

Designing and creating artefacts, according to Oates (2006:108-109), results in the solving of intricate problems. An instantiation artefact will be constructed for the production of a working system that presents constructs, models, methods, ideas, genres and theories that can be implemented in an IS (Oates, 2006:108). The artefact, which will be a fuzzy expert system, will be constructed using a knowledge base that consists of the rules extracted from the literature study to do with decision making and support in the adoption and use of SDMs.

1.5 Conceptual framework

A conceptual framework has been devised for the information gathered in this study. The framework will help to explain the diffusion process with regards to the adoption and use of an SDM. Furthermore, the framework (see Figure 1.1) will allow for the organisation of the information relating to the different factors that influence the adoption and use of an SDM. The framework is based on Rogers' framework for the innovation–decision process (Rogers, 1995:162; Raghavan & Chand, 1989:81-90; Kautz & Larsen, 2000:12-16), as well as on the conceptual research model for the deployment of SDMs, as developed by Huisman and Iivari (2002a:136; 2002b:89). The conceptual framework will deliberate on the different factors that influence the adoption and use of SDMs.

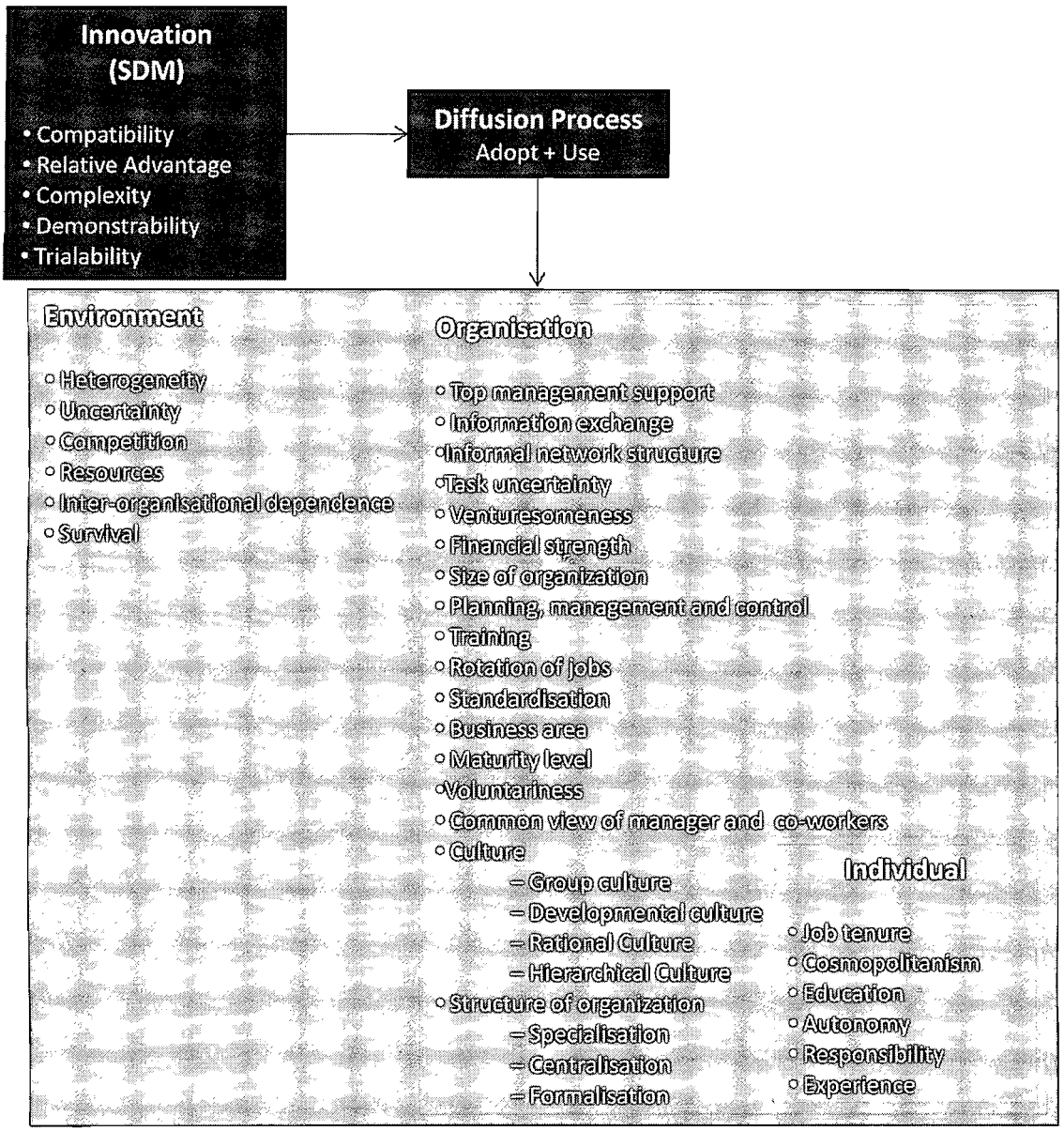

Figure 1.1: Conceptual framework

1.6 Fuzzy expert system

The main objective of the current study was to develop a fuzzy expert system that is capable of predicting whether or not an organisation is ready to adopt and use an SDM. The knowledge base of the fuzzy expert system was based on information gleaned from the literature.

Combinations of the two different SDMs namely that for the general development of a fuzzy expert system (Giarratano & Riley, 2005:359) and the linear model for developing such a system (Giarratano & Riley, 2005:374), were used to develop the fuzzy expert system. The best features of the SDMs were combined to create a new developmental methodology that was used for this study. The reason for developing a new methodology was to capture the best features of each methodology, and to choose the features that were applicable to this study.

The fuzzy expert system was developed in two different programming languages, namely FuzzyCLIPS and C#. The fuzzy expert system part of the system was developed in FuzzyCLIPS, with the user interface being developed in the procedural language C#. The fuzzy expert system portion of the system acts like a template. In other words, the fuzzy expert portion of the system is a fully working system, lacking the input added to execute the system. The user interface receives the user input from the user. Following this, the user interface copies the fuzzy expert system template and adds input at the end of the system for each new entry in the system. The user interface then executes the FuzzyCLIPS complier with the changed fuzzy expert system. After the fuzzy expert system has completed its execution, all of the results are written in a file, which is used by the user interface to display the results.

1.7 Outline of chapters

Chapter 1 provides the motivation, the problem statement and the objectives that were predetermined for the current study. This chapter gives an overview of the study.

The literature review that was conducted is described in Chapter 2, along with the conceptual framework. The method of how the study was conducted is deliberated in Chapter 3. The philosophical paradigm, research method, data collection and an introduction of the fuzzy expert system are deliberated on in the chapter. Chapter 4 describes the fuzzy expert system that was developed, and the method which was followed to develop the system. Chapter 5 concludes the study with the results, contributions, limitations and further research.

1.8 Summary

The development of tools and software aids professionals in the adoption and use of SDMs. Therefore, the focus of the current study is to develop a tool to contribute to the process. Chapter 2 provides a detailed description of the development of a fuzzy expert system that is capable of facilitating the adoption and use of SDMs.

Chapter 2: Literature review

In the IS field, one area of interest is the adoption and use of SDMs. SDMs can be defined as the totality of systems development approaches, including the process model, specified methods and specific techniques (Huisman & Iivari, 2002b:90). Research has shown that an SDM can improve the quality of the systems development process and the quality of systems developed in an organisation, if the SDM is implemented correctly and certain factors are taken into account (Burns *et al.*, 2008:394). The factors that influence the decision to adopt and use an SDM can be classified as follows: organisation; individual, environmental, and innovation. The factors will be dealt with in this chapter. Most of the research that has been conducted into the adoption and use of SDMs is focused on a segment of the factors, so that the outcome of such research is fragmented. An overview of the research that has been done to date in the field of SDMs is provided in this chapter, resulting in the production of a list of factors that might influence the decision to adopt and use an SDM in an organisation. These factors will then be used to build a fuzzy expert system.

2.1 Framework of the study

A conceptual framework has been devised to collate the data collected for this study. The framework will facilitate explaining the diffusion process with regards to the adoption and use of an SDM. Furthermore, the framework (see Figure 2.2) will allow for the organisation of the different factors that influence the adoption and use of an SDM. The framework is based on Rogers' framework for the innovation–decision process (Rogers, 1995:162; Raghavan & Chand, 1989:81-90; Kautz & Larsen, 2000:12-16), as well as on the conceptual research model for the deployment of SDMs, as developed by Huisman

and Iivari (2002a:136; 2002b:89). The conceptual framework will allow for the discussion of the different factors that influence the adoption and use of SDMs.

Rogers' innovation–decision framework depicts five stages, consisting of knowledge, persuasion, decision, implementation and confirmation (see Figure 2.1) (Rogers, 1995:162-163; Raghavan & Chand, 1989:81-83; Kautz & Larsen, 2000:12). This framework has served as the starting point for research into information technology (IT) and ISs (Kautz & Larsen, 2000:12). Diffusion, according to Rogers (1995:10-11), is the process of communicating innovations to social systems, consisting of an information-seeking and processing activity (Kautz & Larsen, 2000:12). The diffusion process, as described by Rogers (1995:162), occurs in the following way. The decisions which are made about innovations are not made instantaneously, but are rather taken over time, including, as they do, certain actions and considerations. The decision making and other innovative stages are depicted in Figure 2.1. The knowledge stage occurs when an individual is exposed to an innovation for the first time. In this stage of the process, an individual becomes aware of the existence of an innovation and accumulates information pertaining to it. Persuasion occurs when the individual forms an opinion about whether the innovation is positive or negative. After forming such an opinion, a decision is taken that will result in either the adoption or rejection of the innovation concerned. If the decision is made to adopt an innovation, the implementation stage follows, in which the innovation is put into use. The final evaluative stage of the innovation–decision process involves the seeking out of confirmation to reinforce that the decision already made has been the correct one.

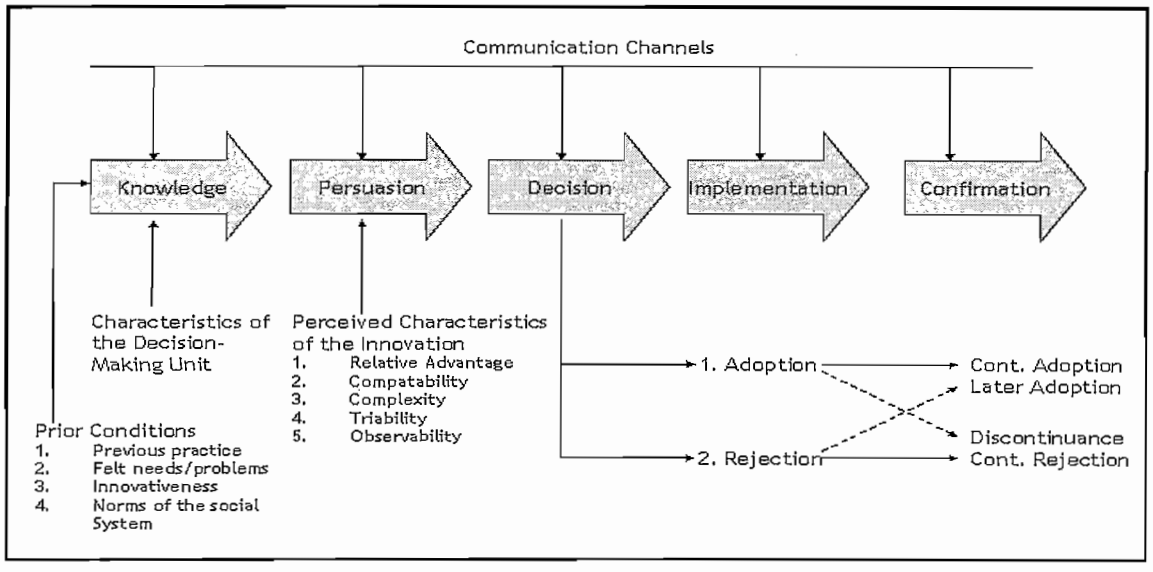

Figure 2.1: Innovation–decision process (Rogers, 1995:162)

Furthermore, Rogers (1995:10-23) has defined four key elements that influence the diffusion process: innovation; communication channels; time; and social systems. Innovation can be described as any idea, object or practice that is perceived to be new to an individual. Communication channels refer to the mediums used by individuals for participating in, and sharing information about, a new innovation, in an attempt to secure mutual understanding about the innovation concerned. The time dimensions describe the amount of time that an individual takes to pass through the stages of the innovation–decision process in order to adopt or reject an innovation. A social system consists of related units, which focus on solving problems by means of a joint effort which is exerted to accomplish the same goal. The decision-making process, as well as the four key elements listed above that play a role in the diffusion of an innovation, will be used to formulate the diffusion portion of the conceptual framework to be used in this study.

The conceptual framework (see Figure 2.2) starts with the innovation. An innovation is an idea, practice or object that influences the employees in an organisation to adopt it (Raghavan & Chand, 1989:83; Kautz & Larsen, 2000:12; Rogers, 1995:11). Furthermore, according to Jayanthi and Sinha (1998:472), an innovation is an idea that

is perceived to be new to an organisation, although it might be an imitation of what already exists. In this study, the innovation studied is SDM. The characteristics of an innovation play a crucial role in deciding whether or not an organisation should adopt it (Kautz & Larsen, 2000:12; Jayanthi & Sinha, 1998:471-472). Five key characteristics that influence the rate of adoption of a new innovation, according to Rogers (1995:206-208), are relative advantage, compatibility, complexity, the ability to try out new innovations; and visibility (Raghavan & Chand, 1989:83; Kautz & Larsen, 2000:15; Rogers, 1995:206-208). The characteristics are enumerated in section 2.2.

In the conceptual framework (see Figure 2.2), becoming aware of an innovation is followed by the diffusion phase (see Rogers' decision–innovation framework, as depicted in Figure 2.1). The elements of the diffusion phase are based on the conceptual research model, which is used in the deployment of SDMs by Huisman and Iivari (2002a:136; 2002b:89). The elements are divided into different phases, which flow chronologically from one another.

The first phase is adoption, of which the primary goal is to decide whether to adopt or reject the new innovation, as well as to commit to the choice regarding the innovation (Jayanthi & Sinha, 1998:472; Raghavan & Chand, 1989:83). During this phase, the potential adopter learns about the innovation and its workings (Raghavan & Chand, 1989:83). After the relevant information has been analysed, the potential adopter either decides to continue with the diffusion process or to reject the innovation, and so terminate the diffusion process (Raghavan & Chand, 1989:83). The adoption phase that follows the becoming aware of an innovation is one of the main focus areas of this study and is influenced by those factors that are pertinent to the innovation.

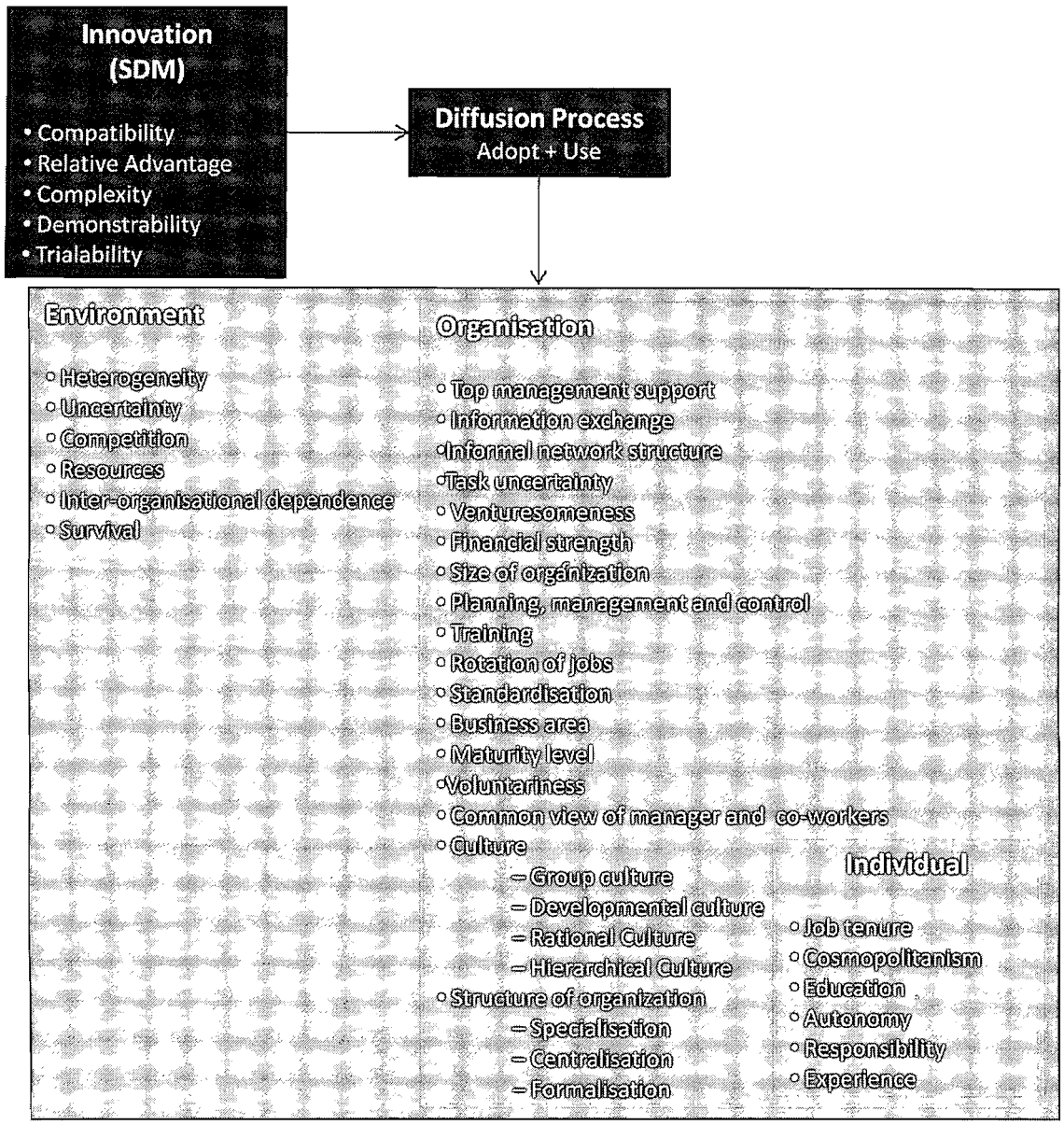

Figure 2.2: Conceptual framework

Subsequent to the formal adoption of the innovation, an organisation might have reservations about the use of such an innovation (Fichman, 1999:18). Thus, the post-adoption process affects the extent to which the technology is accepted in the

organisation (Fichman, 1999:8-15). The use phase consists of two dimensions: frequency of use of the innovation, and the intensity of its use (Huisman & Iivari 2002a:136-138; Huisman & Iivari 2002b:90-92). The use of an innovation is the other focus area of the current study.

The final part of the conceptual framework (see Figure 2.2) consists of the adopting units and the environment in which such units function. An SDM is a continuous innovation, meaning that an organisation must first adopt an SDM before it is adopted by the employees in an organisation. For this reason, it is important that the study focuses on the two adopting units. Furthermore, the adopting units function in a specified environment that influences them. Due to such an influence, the characteristics of the environment must be taken into account in the study. Such characteristics influence the adoption and use of SDMs. The adopting units are both organisational and individual. The following sections of this dissertation will discuss the innovation characteristics; the organisational adopting unit; the individual adopting unit; and the environment.

2.2 Innovation factors (SDM characteristics)

An innovation is the idea, practice or object which will influence people in an organization to adopt these new ideas, practise or objects (Raghavan & Chand, 1989:83; Kautz & Larsen, 2000:12; Rogers, 1995:11). The adoption and use of an innovation depends on the factors of compatibility, relative advantage, complexity, demonstrability and trialability (Kautz & Larsen, 2000:12; Jayanthi & Sinha, 1998:471-472). The named characteristics are discussed in this section.

2.2.1 Compatibility

The compatibility of the innovation in terms of the organisation has a significant influence on whether the innovation is adopted (Bonner, 2008:53; Kwon & Zmud, 1987:237). Equally important is the compatibility of an SDM, which refers to its consistency with the developer's previous software development (Chan & Thong, 2009: 809). This factor, which is called the innovation's organisational 'fit', matters on both the organisational and the individual level (Kwon & Zmud, 1987:237; Ramiller, 1994:5). Furthermore, compatibility is the degree to which an innovation is consistent with the values, experiences and needs of an organisation, which impacts on whether the innovation is adopted (Huisman & Iivari, 2002a:138; Huisman & Iivari, 2002b:90; White *et al.,* 2007:76). Huisman and Iivari (2002a:138; 2002b:90) also describe the compatibility of an innovation and organisation as the 'fit' between the innovation and the adoptees, which implies that the innovation should match the context of the organisation to be successful (Huisman & Iivari, 2002a:147; Huisman & Iivari, 2002b:99).

At an individual level, the compatibility of an SDM is related to the perceived impact of the methodology on the development of a system and the development process (Huisman & Iivari, 2002a:138). Compatibility does seem to influence the individuals' compliance to the adoption and use of an SDM (Huisman & Iivari, 2002a:138). When methodologies are highly compatible with the developers' way of work, the individual can perceive the SDM as routine (Huisman & Iivari, 2002a:147). At an organisational level, compatibility describes the lack of gap between the social–technical systems structure and the way in which the structure can accommodate the innovations, which can also be referred to as the innovation's 'fit' to an organisation (Ramiller, 1994:5). If an innovation is compatible with an organisation, adopting such an innovation is likely to be more profitable for it (Kwon & Zmud 1987:237). Furthermore, the compatibility of an SDM has been shown to have a positive effect on the adoption and use of the methodology concerned. Such a finding is supported by Bonner's (2008:93) study, which concluded that compatibility positively affects individual competence. If a methodology is compatible with an organisation, those employees concerned should feel encouraged to

use it (Bonner, 2008:70). Compatibility, accordingly, has a positive role to play in the adoption and use of SDMs.

2.2.2 Relative advantage

The perceived benefit that an innovation can provide to an organisation is called the relative advantage of the innovation (Bonner, 2008:53; Kwon & Zmud, 1987:237). Such costs and benefits can include economic, social and political legitimacy. According to Huisman and Iivari (2002a:141, 2002b:90) and White *et al.* (2007:76), relative advantage refers to the degree to which an innovation is better than the idea which it supersedes.

According to Kwon and Zmud (1987:237) and Bradley and Hauser (1995:161-163), the more relative advantage an innovation has for an organisation, the better are the chances of its adoption. Furthermore, in a study conducted to establish the relationship between relative advantage and individuals, relative advantage was found to relate positively to an individual's innovativeness (Karahanna *et al.,* 2002:336). The existence of relative advantage encourages individuals to be more open to the adoption and use of innovations. If an SDM provides an advantage for an individual, the individual is then prepared to use the SDM to gain the advantages of the use of such a methodology (Huisman & Iivari, 2002a:147; White *et al.,* 2007:76). Furthermore, an innovation is positively accepted in an organisation due to the relative advantage of the innovation for the organisation (Huisman & Iivari, 2002a:141; Huisman & Iivari, 2002b:99). Huisman and Iivari (2002a:141; 2002b:99) also found that a strong positive relationship exists between deployment and relative advantage with respect to the use and acceptance of an SDM in an organisation. Relative advantage encourages the adoption and use of an SDM in an organisation.

2.2.3 Complexity

Complexity refers to the degree of difficulty involved in understanding and using an innovation (Bonner, 2008:53; Kwon & Zmud, 1987:237). The likelihood of an innovation being adopted and implemented decreases if the innovation is too complex for the organisation concerned (Huisman & Iivari, 2002b:90; White *et al.,* 2007:76). If the SDM is perceived as requiring a lengthy learning curve by the adoptees, the SDM will, most probably, not be used (Huisman & Iivari, 2003a:59-60).

The difficulties experienced by the adopter and users have a negative effect on the adoption and use of an innovation. The more complex an innovation is, the more difficult it is for the organisation to adopt it (Kwon & Zmud, 1987:237). Huisman and Iivari (2002b:99) discovered that no significant negative relationship existed between the deployment of an SDM and its complexity. Furthermore, in Huisman and Iivari's (2003a:59) later study, they listed several factors, including complexity, that could negatively influence the adoption of an SDM. However, the study also showed that organisations tended not to find methodologies too hard or complex to understand (Huisman & Iivari, 2003a:59). In support of such an argument, Bonner (2008:69-70) found that the complexity of an SDM negatively affects individual competency. Accordingly, complexity negatively impacts on the individual use of an SDM (Bonner, 2008:69-70). Therefore, the complexity of an SDM, as perceived by an organisation, negatively affects the adoption of an SDM, requiring it, as an organisational factor, to be taken into account in the adoption and use of an SDM.

2.2.4 Demonstrability

Demonstrability refers to the visibility of the results of an innovation (Huisman & Iivari, 2002a:139). Furthermore, demonstrability can also be referred to as the signs of tangible advantage (Chan & Thong, 2009: 809). The easier it is to see the results of the use of an SDM, the easier it is for an individual to adopt such a methodology (Huisman & Iivari, 2002a:139). The results achieved in terms of demonstrability are the same as those

achieved in terms of complexity, with it not having a significant effect on the individual in the adoption of a methodology (Huisman & Iivari, 2002a:147). Therefore, demonstrability will not be treated as a relevant factor in the adoption process in the current study.

2.2.5 Trialability

The trialability of an SDM is the degree to which a methodology can undergo experimentation on a trial basis (Huisman & Iivari, 2002a:147; Bonner, 2008:69-70). The more trialable a SDM is, the greater are the chances that it will be adopted (Huisman & Iivari, 2002a:147). Huisman and Iivari found that the trialability of an innovation relates positively to its adoption and use. In addition, White *et al.* (2007:76) found that trialability positively affects the adoption of an SDM. Trialability will be considered to have a positive effect on adoption of a SDM.

2.3 Organisational factors

According to Huisman and Iivari (2002a:141), an organisation consists of different influences and social groups that cooperate in achieving the organisational goals. Such influences and social groups can consist of top management, supervisors, peers and friends. In this study, such influences and social groups will be referred to as organisational factors. In this section, such factors are described in regards to the influence that they have on the adoption and use of SDMs.

2.3.1 Top management support

Top management support consists of the support provided by top management for the adoption and use of an innovation. Such support helps to ensure the successful implementation of an IS (Chen & Thong, 2009: 809; Kwon & Zmud, 1987:228; Bradley & Hauser, 1995:163). According to Roberts *et al.* (1998:644), an IS manager is one who is

empowered with the responsibility for implementing an SDM. An IS manager who wishes to implement a new SDM should be directly involved with the implementation process (Roberts *et al.,* 1998:644). The lack of management support is considered as one of the major obstacles to the successful deployment of an SDM (Huisman & Iivari, 2002a:141). Such a lack of support has a significantly negative effect on the deployment of an SDM at an individual and organisational level (Huisman & Iivari, 2002a:147; Huisman & Iivari, 2003a:59-60). Furthermore, Huisman and Iivari (2002a:147) identified a positive relationship between top manager support and the deployment of an SDM, resulting in their conclusion that such support positively influences the use of SDMs. Managerial involvement encourages the adoption of a positive attitude among employees regarding their adoption, acceptance and satisfaction of the SDM concerned (Kwon & Zmud, 1987:234). Opinion leaders or authoritative individuals influence the diffusion of innovations and help to determine the outcome of such diffusion (Raghavan & Chand, 1989:85). The managerial support of SDMs is crucial to their successful adoption and use.

2.3.2 *Information exchange among designers and users*

Information exchange among system designers and users aids in the successful implementation of an IS (Kwon & Zmud, 1987:229). Such exchange includes consideration of the purpose, objectives, and impact of the system, aimed at helping both designers and users to reach a mutual understanding about the IS concerned (Kwon & Zmud, 1987:229). The SDM can be used for such an exchange (Kwon & Zmud, 1987:229-232). Bygstad *et al.* (2008:382), found in their investigation of the relationship between development methodologies and the usability of systems, that such usability was very important to organisations. Furthermore, they found that SDMs and system usability integrally contributed to the understanding of user requirements (Bygstad *et al.,* 2008:382). Information exchange among designers and users, therefore, is taken as positively affecting the adoption and use of SDMs.

2.3.3 Informal network structures

Informal network structures are viewed as the communication of innovations and information transfer, in which individuals communicate the idea of adoption among the adopters (White *et al.,* 2007:76; Kwon & Zmud, 1987:236). The existence of such a network is a key contributing factor to the diffusion of new innovations among adopters (Kwon & Zmud, 1987:236). To encourage understanding of an innovation among employees in an organisation, such a network can serve as a reliable and legitimate way in which to spread the word about the coming change among them (Kwon & Zmud, 1987:236). A positive association with adoption has been found in the adopters' behaviour if a change is communicated in such a way (Kwon & Zmud, 1987:236). In support of such an argument, Joshi *el al.* (2007:330) showed that knowledge transfer by means of frequent communication among developers positively affects individuals. Furthermore, the knowledge transferred from the team leader to the development team improves the visibility of team performance (Joshi *et al.,* 2007:330). The diffusion of innovation requires a communication channel that transmits information about innovations (Raghavan & Chand, 1989:83). The communication process used to communicate information about the innovations adopted, or the informal network, as indicated by Kwon and Zmud (1987:236), should consist of different users, potential adopters, and the communication channels, which will allow the relevant information to be spread throughout the organisation (Raghavan & Chand, 1989:83). The informal network structures which are in place to communicate information about innovations are taken as facilitating the adoption of an innovation.

2.3.4 Task uncertainty

Task uncertainty relates to the routine and programmable nature of the tasks that an organisation has to execute to complete its day-to-day functions as well as to conduct its decision-making activities (Kwon & Zmud, 1987:238). The more routine a task becomes, the more resistant to change individuals grow (Kwon & Zmud, 1987:238-239). The more routine the tasks, the easier it is to obtain satisfaction from the adoption of a new SDM.

However, due to resistance to change, such adoption remains problematic (Kwon & Zmud, 1987:238-239). In contrast, if the task at hand is difficult and breaks the routine, the individual concerned would most likely be motivated to initiate a solution for the problem (Kwon & Zmud, 1987:238-239). Therefore, task uncertainty can positively influence the implementation and use of an innovation if the difficulty of the task at hand precedes the normal activates of an organisation, especially in relation to IT (Kwon & Zmud, 1987:237). Task uncertainty, therefore, can have a positive effect on the adoption and use of SDMs.

2.3.5 Venturesomeness

Venturesomeness is the capacity of an organisation to foster the trying out of new and different things (Raghavan & Chand, 1989:84-85). Such an organisation usually falls into the early adopters' category, according to Rogers' innovation–adoption curve, which indicates the rate and stages at which an innovation is likely to be adopted in an organisation (Raghavan & Chand, 1989:84-85). The early adopters are those organisations that stand to profit from the innovation, which results in the facilitation and speeding up of the process (Raghavan & Chand, 1989:84-85). The venturesomeness of an organisation positively affects the adoption and use of an SDM.

2.3.6 Financial strength

Financial strength refers to the possession of extensive resources by an organisation. Financially strong organisations usually invest more in research and development (Raghavan & Chand, 1989:85). Such organisations are defined as early adopters in terms of Rogers' innovation–adoption curve, as they are likely to profit substantially from such a move (Raghavan & Chand, 1989:85). Financial concerns are important to an organisation considering the adoption of an SDM, especially considering the large amount of investment that such an adoption takes (Huisman & Iivari, 2003a:57). Investment in an SDM is long-term, whereas costs are inherently short-term (Huisman &

Iivari, 2003a:57-59). For such reasons, an organisation with a strong financial background is more likely to adopt a new SDM.

2.3.7 Size of the organisation

The size of an organisation refers to the amount of resources and the number of people in the organisation. (Raghavan & Chand, 1989:85). If an organisation is the largest in the marketplace, the chances of adoption increase dramatically, with the organisation concerned being classified as an early adopter, according to Rogers' innovation–adoption curve (Raghavan & Chand, 1989:85). Larger organisations tend to have more resources available for supporting the investment that is required for the adoption of an innovation (Rai & Howards, 1994:135; Rahim *et al.,* 1998:952). Rai and Howards (1994:143) indicate the positive relationship between the size of an organisation and the adoption of innovation (Rai & Howards, 1994:135). They found that the larger the firm, the more likely it was to adopt an innovation (Rai & Howards, 1994:135).

The size of an organisation refers to, among other factors, the number and amount of available resources (Huisman & Iivari, 2002b:92; Rahim *et al.,* 1998:952). Small organisations generally do not adopt SDMs because their IS departments are too small to execute the methodology properly (Huisman & Iivari, 2003a:57-58; Rahim *et al.,* 1998:953). In addition, Fitzgerald (1998:322) found that usage of SDMs were significantly influenced by the size of the organisation and the IS department. The study indicated that the larger the organisation and IS department the more likely it was that the organisation would use SDMs (Fitzgerald, 1998:322). Therefore, the size of the organisation is taken as playing a significant role in the adoption and use of innovations.

In contrast to the size of an organisation, Huisman and Iivari (2002b:99) found no relationship between the size of an IS department and the deployment of an SDM. Although a negative relationship was indicated between the size of an IS department and the use of an SDM, it was also found that the smaller the size of an organisation, the

more likely it was to use the SDM (Huisman & Iivari 2002b:98-99). Although SDMs are usually developed for large IS departments, the use of innovations is usually the same throughout IS departments. The outcome of such innovations tends to increase the quality and productiveness of development in small IS departments (Huisman & Iivari 2002b:98-99). The larger an organisation is, the greater the positive affect tends to be on the adoption and use of SDMs.

2.3.8 Planning, management and control

Planning, management and control in IS projects has been found to play a significant role in the adoption of methodologies (Burkhard, 1990:419). Generally, planning tends to be a prerequisite for quality control in the development of an IS, but adopting a methodology might make planning mandatory (Burkhard, 1990:419-420). Organisations try to counteract industry and global economic pressures, with the objective of remaining competitive. Planning and control is one method of achieving such a goal (Burkhard, 1990:419).

The planning and management of an IS department tends also to be directed at preventing maintenance costs, which, on average, consume 80% of available resources (Burkhard, 1990:425). To achieve such goals, a methodology might help with the planning, management and control of an IS project, usually leading to the adoption of the methodology concerned (Grant & Ngwenyama, 2003:31; Burkhard, 1990:421-425). Furthermore, in a study conducted by Fitzgerald (1998:320), the results showed that SDMs were more used for corporate planning management and project control where the project development was to continue for a long time (Grant & Ngwenyama, 2003:31; Fitzgerald, 1998:230).

2.3.9 Training

A negative relationship between technology and innovations might be overcome by training, which is the formal procedure by which an organisation standardises the learning of its employees to ensure that the goals and objectives of the organisation are reached (Chan & Thong, 2009:809). The organisation might show a symbolic

commitment to the use of innovations and technology by the training that it provides its employees (Rai & Howards, 1994:136).

An increase in the acceptance of innovations and the use of technology in organisations can be achieved by training designers and analysts (Bradley & Hauser, 1995:163). Such increased acceptance also helps the designers and analysts to learn skills and techniques for using the innovations more productively and for increasing the acceptability of the innovation (Rai & Howards, 1994:136). In addition, Huisman and Iivari (2003a:58), as well as Lee and Truex (2000:360-361), stipulated that formal training was essential and that a lack of software engineering methods or engineering tools training could lead to SDMs not being used in an organisation. Educating and training system developers in the new methodology to prevent the developers from reverting to the previous development practices should provide a good start for introducing and enforcing new SDMs in an organisation (Lee & Truex, 2000:360-361; Huisman & Iivari, 2006:41; Grant & Ngwenyama, 2003:31). Thus, training in the specific SDM is important and increases the chances of the methodology being both accepted and used by the system designers and analysts after the training.

2.3.10 Rotation of jobs or roles

The degree to which an organisation rotates job or roles in an information department impacts on the extent to which innovations are used (Rai & Howards, 1994:143). If individuals rotate job descriptions, they can develop an appreciation of the different tasks and functions in the information department and of the way in which they relate to each other (Rai & Howards, 1994:137). Developing such an appreciation might help the individuals in the organisation to be more open to change in respect of any organisational structure, such as the adoption of an innovation (Rai & Howards, 1994:137). Furthermore, the blending of job roles might diversify the degree to which an information department might be encouraged to specialise (Rai & Howards, 1994:137–138,143). Finally, individuals are more likely to be open to change, in that they will not

feel as though their skills are obsolete and restricted and that they might be retrenched, due to their experience in other areas of the department (Rai & Howards, 1994:136-137). The rotation of jobs has a positive effect on the adoption and use of SDMs.

2.3.11 Standardisation

The implementation of SDMs aids in the standardisation of development and helps with system backlogs in an organisation (Roberts *et al.,* 1998:641). In standardising development, an organisation needs to implement an SDM (Roberts *et al.,* 1998:644). Such implementation would help an organisation to integrate business and IS design models (Roberts *et al.,* 1998:644). It would also allow for the successful use of automated tools for the development of the system (Roberts *et al.,* 1998:644). To improve the standardisation of systems development, an organisation should implement an SDM. The need for the standardisation of an organisation positively influences the adoption and use of SDMs.

2.3.12 Business areas

The type of business conducted has a significant influence on the IS structures used in an organisation (Huisman & Iivari, 2002b:97). Business areas include administrative services; manufacturing; finance\banking\insurance; retail\wholesale; and software housing\manufacturing (Huisman & Iivari, 2002b:91-92). The existence of such an influence is supported by various research studies, which have found that the financial sector in which the business is engaged has a significant influence on the IS operations concerned (Huisman & Iivari, 2002b:91-92; Rahim *et al.,* 1998:952). It was found that the nature of the business sector in which the organisation operates is significantly related to the use of systems development methodologies (Huisman & Iivari, 2002b:92). Fitzgerald (1998:230) agrees that the relationship between business areas and the use of SDMs is significant, with some business areas using SDMs more than others do (Fitzgerald, 1998:230).

Seyal *et al.* (2000:10) found that different business sectors have different uses for SDMs. Rahim *et al.* (1998:952) found that those government agencies that are involved in the administration and financial services sectors are major users of SDMs (Huisman & Iivari, 2002b:92). Furthermore, classifying the business areas of an organisation is important; as such classification affects the adoption of SDMs of each business area differently (Rahim *et al.,* 1998:952). The business area involved affects the frequency of use of SDMs (Huisman & Iivari, 2002b:99).

2.3.13 Maturity level

Paulk *et al.* (1993:20) define the maturity of an organisation as "the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective." The maturity level of IS development in an organisation plays a role in the adoption and use of SDMs (Fitzgerald *et al.,* 2002:82; Huisman & Iivari, 2002b:92-93). According to Huisman and Iivari (2002b:92-93), an organisation can be at any one of a number of different levels of maturity, which impacts on whether the adoption and use of an SDM will be successful. If an organisation is in the initial level of maturity, it would be highly unlikely to be able to adopt and use and SDM, due to the lack of structure and planning (Fitzgerald *et al.,* 2002:82; Huisman & Iivari, 2002b:92-93; Huisman & Iivari, 2003a:58). As an organisation matures, the more likely it is that it will use an SDM (Fitzgerald *et al.,* 2002:83; Huisman & Iivari, 2002b:99; Huisman & Iivari 2003b:383). The maturity level of the organisation also influences the cultural factors in adoption, which will be discussed in subsection 2.4 of this dissertation. As has been indicated, the more mature an organisation is, the more likely it is that the organisation will adopt and use an SDM (Huisman & Iivari, 2007:39,46; Huisman & Iivari 2003b:383).

2.3.14 Voluntariness

Voluntariness is the extent of voluntary use and acceptance of an innovation, which indicates the free will to use it (Huisman & Iivari, 2002b:94; Huisman & Iivari, 2002a:141-142). In addition, voluntariness can also be described as the extent to which an

innovation is perceived to be non-mandatory by its adopters (Chan & Thong, 2009:809). Voluntariness affects the degree of acceptance and use of SDMs at both the individual and the organisational level (Huisman & Iivari, 2002b:94). SDMs of which the use is not mandated by management are unlikely to be used, because the developers will not fit them into their schedules (Huisman & Iivari, 2002b:94; Huisman & Iivari, 2006:44). Thus, the factor requires consideration and plays a major role at organisational level in the use of an SDM, though its effect on the acceptance of a methodology is minimal (Huisman & Iivari, 2002b:99). Furthermore, Huisman & Iivari (2002a:147) found, at the individual level, that voluntariness has no influence on the adoption and use of an SDM. Accordingly, voluntariness is taken to have a positive effect on the adoption of an SDM.

2.3.15 Common view of managers and co-workers

A critical success factor for the implementation of SDMs is the view that is held in common by both managers and workers, which is also called perceptual congruence (Huisman & Iivari 2006:31). Perceptual congruence has a positive effect on an organisation regarding SDMs, as any uncertainty and ambiguity between individuals is then minimised (Huisman & Iivari, 2006:30). Equally important are the findings of Kautz *et al.* (2004:16), who say that such a view facilitates the use of SDMs. Furthermore, the developer's desire for involvement and cooperation with managers regarding SDMs promotes the use of the methodology (Kautz *et al.,* 2004:13). In conclusion, the view that is held in common by both managers and workers advances the adoption and use of SDMs.

2.4 Organisational culture

Two frameworks exist in terms of which the culture of an organisation can be measured, that of competing values and that of the dimensionalising of cultures, the latter of which can also be referred to as the Hofstede dimensions (Hofstede, 2009). The five

dimensions of the latter are power distance; uncertainty avoidance; individualism versus collectivism; masculinity versus femininity; and long term versus short term (Hofstede, 2009). The competing value framework consists of four dimensions, namely group culture; developmental culture; rational culture; and hierarchal culture (Cameron *et al.,* 2006:46; Dastmalchian *et al.,* 2000:390).

As organisational culture can be interpreted as consisting of almost everything in an organisation, it can play a significant role in the adoption process (Fitzgerald *et al.,* 2002 114; Huisman & Iivari, 2007:36; Chen & Thong, 2009:809). This study uses the competing values framework, because such a framework is more applicable in the IS research field (Dastmalchian *et al.,* 2000:390-392). The dimensions of the competing value framework will be discussed in the next section of this dissertation.

2.4.1 Group culture

The group culture is primarily focused on human relations and flexibility (Huisman & Iivari, 2002b:93, Huisman & Iivari, 2007:37; Cameron *et al.,* 2006:41; Dastmalchian *et al.,* 2000:390). The core values associated with such a culture are those of the individual, trust and participation. Another aspect of the group culture consists of effectiveness, including the development of human potential and the commitment of the members of a specific IS department (Huisman & Iivari, 2002b:93, Huisman & Iivari, 2007:37; Cameron *et al.,* 2006:41; Dastmalchian *et al.,* 2000:390). According to the findings of Huisman and Iivari (2002b:99; 2007:47), the group culture plays no significant role in the adoption of SDMs. Group culture will, therefore, be treated as a neutral factor, with no significant influence on the adoption of SDMs.

2.4.2 Developmental culture

Developmental cultures focuses on what might happen in the future (Huisman & Iivari, 2002b:93, Huisman & Iivari, 2007:37; Cameron *et al.,* 2006:39-40; Dastmalchian *et al.,* 2000:390). The effectiveness aspect of such a culture includes an emphasis on growth,

the acquisition of resources, the creative capabilities of individuals, and the adoptive aspects of the external environment (Huisman & Iivari, 2002b:93, Huisman & Iivari, 2007:37; Cameron *et al.*, 2006:39-40; Dastmalchian *et al.*, 2000:390). The developmental culture was found not to impact on the adoption and deployment of SDMs as drastically as was envisaged (Huisman & Iivari, 2002b:99). However, it was found that a positive correlation could be drawn between the developmental culture and the deployment of SDMs, though not systematically (Huisman & Iivari, 2007:42).

2.4.3 Rational culture

The rational culture emphasises individual achievement (Iivari, 2006:659; Huisman & Iivari, 2002b:93, Huisman & Iivari, 2007:37; Cameron *et al.*, 2006:42-43; Dastmalchian *et al.*, 2000:390). Focus areas of the rational cultures are the productivity and efficiency of the IS department, and the achievement of goals. The rational culture is very negative regarding the use and adoption of SDMs (Huisman & Iivari, 2002b:99). In a later study conducted by the two researchers (Huisman & Iivari, 2007:47), it was found that the rational culture is hostile towards the adoption of SDMs. Accordingly, the use and adoption of SDMs were found to be very negatively affected by a rational culture.

2.4.4 Hierarchical culture

A hierarchical culture emphasises the maintenance of security, order and routine in the workplace (Iivari, 2006:659; Huisman & Iivari, 2002b:93, Huisman & Iivari, 2007:37; Cameron *et al.*, 2006:37-38; Dastmalchian *et al.*, 2000:390). Hierarchical cultures follow rules and regulations to emphasise control, stability and efficiency. Due to the strong focus on rules and regulations for control and stability, this culture has a very strong positive association with the use and acceptance of SDMs in the adoption process (Huisman & Iivari, 2002b:99; Huisman & Iivari, 2007:47).