An Approach to ERP Readiness using Situational Method Engineering: Si-MERM

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ABSTRACT
The purpose of this article is to design a context-aware ERP readiness management (ERM) model. This issue comes from a challenge observed in the literature where ERP readiness methods struggled to adapt going from one context to another. The question is tackled with a focus on contextual variables like economy, culture, human resource and infrastructure. Situational Method engineering (SME) is used to decompose existing methods into reusable components with contextual properties. The Design Science methodology is used to combine these components within a situational framework composed of a metamodel, a repository and an assembly algorithm. Experiments are used to evaluate the model towards its capacity to describe existing ERM. SME combined with ERM offers new capabilities to ERM models. This study hence contributes with an approach to build an ERM by assembling components based on their suitability to a particular context. It is also the first to combine SME with ERM to contribute to an adaptability issue.

Keywords
Erp implementation failure, Erp readiness, Situational Method Engineering, Design science.

1. INTRODUCTION
ERP systems are highly adopted worldwide but, despite a growing interest, most implementation attempts have failed [1]. Statistics show that between 60% and 90% of ERP implementations fail [2,3], with consequences for the organization and its employees. For example, Cameroonian public services failed to implement an Sap Erp by losing more than \$3 millions [4].

One way to address the failure is by solving identified causes [5,6] and one of the main cause of failure is the organization's non-readiness to implement Erp systems [7,8]. It is one of the most important causes because of its impact on other issues like Erp selection and Erp misfits [9].

Erp readiness management (ERM) involves assessing the organization's level of readiness using mathematical methods and defining ways to improve it, if it is deemed to be low. The state presents several contributions in the field: some articles focused on identifying the factors that need to be considered in a readiness process [10,11,12], others defined models for readiness assessment [13,14,15] and others focused on ERP readiness improvement [16].

In-spite of the evolution of the field, most of the organizations keep failing to implement ERP systems. This might suggest difficulties to adopt, use or adapt existing models going from a context to another one [10,17]. The purpose of this article is to tackle this gap by introducing contextual properties in an ERP readiness life-cycle to make these methods much easier to adapt going from one context to another.

In what follows, the first section presents the scope of contextual aspects to consider and analyze their impact on existing methods. After this section, the research approach and methodology are presented. The next section presents the model developed which is next verified. The article ends with a section that discusses on the impact of the results and research perspectives.

2. LITERATURE REVIEW
This section analyses how differences between contexts can limit the usefulness of an ERM method by initially defining the contextual variables of interest and assessing the level of suitability of existing methods.

2.1 The context
The contextual dimensions considered are economy, infrastructure, human resource and culture, because of their impact on an ERP implementation process [18]. To manipulate them, they are introduced into a practical framework inspired by the one used in [19] used to classify components of agile software methods using *axes*. Axes represent a set of *facets* or observable attributes described in a *domain*. A domain can be a simple type (Integer, Boolean, ...), a structured type (SET or TUPLE) or an enumerated type (ENUM{values}). The axes are described below:

- Economy: Mostly analyzed using the Total cost of ownership (TCO) which includes aspects like the cost of the package (the license), materials, consultancy... The higher the cost, the less likely it is for a low-budget organization to adopt the system. The facet of interest in this case is the budget which varies between organizations hence: *Organization_budget_level = ENUM {LOW, MEDIUM, HIGH }*
- Infrastructure: The infrastructure useful for an ERP implementation are network infrastructures, server platforms, database management systems, client platforms and web technologies... These increase the TCO and depending on the project, the need on infrastructure may change; it can be high in some while being low in others hence the following:

  Organization_infrastructure_level = ENUM{LOW, MEDIUM, HIGH}
- Human resource knowledge: It also varies according to the project. Some contexts are characterized by a lack of experience and maturity in ERP projects and a shortage of skilled personnel which is not the case everywhere. Depending on whether skilled and experienced people are available, the method adopted should adapt to these variations. Accordingly, the value domains of the two facets aim to measure their level, which can be low, medium or high, as presented below: *Erp_skills =*

ENUM{LOW, MEDIUM, HIGH}, Erp_experience = ENUM{LOW, MEDIUM, HIGH}

- Culture: It is defined as a collective mental programming shared by members of a nation, region or group that distinguishes them from others [20]. According to this theory, several dimensions can be used to analyze the national culture of an organization, in this article the focus is made on power distance (PD) and Individualism vs collectivism (IvC). These dimensions reflect the influence that a group or a person might have on a stakeholder; This increases the level of bias of the stakeholder and risks of failure. The notion of *subjectivity* is introduced, which is a person's will to act or to be an actor, as a characteristic value of this dimension. A subjective culture is corrupted, with an impact on processes that need human interventions like data collection. A subjective culture has a high PD or IvC. It is *highly subjective* when both values are high, and *objective* when these values are low. The main facet of this axis is *Human Culture (HC) Orientation* defined as follows: *Human_Culture_Orientation = ENUM {HIGHLY_SUBJECIVE,SUBJECIVE, OBJECTIVE}*.

The framework derived from this analysis is resumed in the table 1.

Table 1. The Context analytical Framework

Axis	Facets	Measures	Questions
Economic	Organization Budget level	Low, Medium, High	To what extent are the organization's budget variations taken into account in the method?
Infrastructure	Organization Infrastructure level	Low, Medium, High	To what extent are the Organization's infrastructures variations are considered in the method?
Human Resource	Erp skills level	Low, Medium, High	To what extent are human skills levels are considered in the method?
	Erp experience level	Low, Medium, High	To what extent are human experiences levels in ERP implementation are considered in the method?
Culture	Human Culture Orientation	Highly Subjective (High corruption), Subjective (Corrupted), Objective (less corruption)	To what extent are culture variations handled by the method?

2.2 ERM Methods analysis

Several contributions have been made, but in this section the focus is on existing ERM methods and models described chronologically. In 2009, [21] assessed an organization's readiness to implement an ERP system using four dimensions (*organization, system, change and project*) derived from a literature review on Critical Success Factors (CSF). Their methodology suggests forming a group of experts with knowledge of both business and technical aspects. The ANP (Analytical Network Process) model was introduced to organize the dimensions hierarchically and to consider links between them. At the end of the process, a readiness ratio is computed. This method comes with some limits: (1) the dimensional model is limited to four dimensions and might avoid important organization's aspects, (2) data comes from experts (this can be problematic in low economy and HR contexts) with risk of bias in subjective contexts, (3) the approach does not show more details about the profile of expertise needed.

In 2011, [22] suggested a method based on the McKinsey 7s model. This model consists of seven (7) dimensions that reflect organizational aspects that are difficult to change such as *shared values, skills, people and style* and those that are much easier to change such as *strategy, structure and systems*. A 5-point scale questionnaire is used to collect data on readiness dimensions and a mathematical formula is used to compute the final readiness using the propensity of each factor. This approach treats the readiness dimensions holistically, and offers a simple calculation process, which is open to users with less expertise. It best suits to objective contexts while neglecting subjective ones in the data collection process. There is no way to improve readiness and the dimensional model used can be too large for a small organization.

In 2013, [23] proposed a method of four steps: (1) identify the determinants of ERP implementation readiness, (2) build an assessment tool based on the previous, (3) weight each determinant, (4) build scoring schemes for each determinant. In their method, the authors built a fuzzy-based ANP model and the readiness factors examined were from three categories, namely *project management, organizational and change management readiness*. The model was validated in a case study with recommendations for the SME case. This approach is limited to readiness assessment and might not suit in contexts with lack of experts.

In 2014, [16] focused on readiness improvement. They defined a way to achieve the highest level of readiness at the lowest cost using the FCM (Fuzzy Cognitive Map) inference model and NSGA-II (Non-dominated Sorting Genetic Algorithm 2). Experts are used for determining the current state of each factor and the degree of causal relationships between them using linguistic variables. The readiness factors used are (1) a well-defined project, (2) clear business strategy and strategic goals of an ERP implementation project, (3) existence of appropriate systems and processes in the organization, (4) culture and structures aligned with ERP project requirements, and (5) sufficient level of human resource support. Having established the level of readiness, this approach offers a way to define a plan to achieve the highest possible level of readiness at the lowest cost. This method requires a high level of economic and human resources capacity and it does not consider subjective contexts when the source of information is corrupted.

In 2015, [24] proposed a method for readiness assessment. In this method, the readiness dimensions and their causal relationships are defined with the help of expert judgments using a FCM (Fuzzy Cognitive Map) model. It also introduces DEMATEL (Decision-Making Trial and Evaluation Laboratory) to rank readiness activities and block modeling techniques to cluster them into manageable groups. Compared to the previous ones, this approach brings more flexibility in terms of context awareness; it helps an organization to build its own assessment model. In their study, the authors used three dimensions, namely (a) organizational readiness, (b) social readiness, and (c) technical readiness. This approach has a number of limitations, which are outlined below: (1) there is no precise way to improve readiness, (2) The need for experts and the models used demand for at least a medium level of IT staff and budget, (3) data gathered from experts are uncertain in a highly subjective context because the source of data might be corrupted.

In the same year, [25] improved the previous method by deriving activities from functional areas like planning, staff, technical requirements, strategic alignment, top management support, processes and structures, data management, consultants. The idea is to improve the most efficient readiness activities with the highest impact. The method uses models like FCM, and FAHP (Fuzzy AHP) to formulate relationships and assess contribution weights between activities. The main limitations identified are the following: There is a lack of solution for readiness improvement; the method neglects contexts with low HR capacity; highly subjective contexts are not considered. Also, this approach inherits the limitations of the previous one. It takes into account the subjectivity of data collection, while neglecting the risks of subjective sources, such as in highly subjective contexts.

In 2020, [15] proposed a dimensional model consisting of CSFs grouped into the following dimensions: Top Management, Project Management, People, Change Management and Technical Requirements. The authors introduced AHP to calculate the weights of the readiness factors, sub-factors and questions, which are then used to compute the final readiness level. The limitations of this method are as follows: (1) the method does not include readiness improvement; (2) The focus is on objective contexts. This is because, data comes from a small group of people in a decision-making group. In this case, there is no way of anticipating the risks of poor quality of the data provided. It hence neglects the importance of users, who need to be involved in order to increase the project's chances of success.

In 2022, [13] used the Technology Readiness Index (TRI) to measure user readiness for ERP implementation in a marketing department. The TRI constructs are optimism, innovativeness, discomfort and uncertainty. The authors introduced a questionnaire using these constructs, in a Likert scale format and validated using SPSS (Statistical Package for the Social Sciences) and Pearson's formulas for correlation test. The results of this study highlight the positive effect of innovation on user readiness in this context, while the other factors had a negative effect. The method is limited to readiness assessment and might be difficult to use in subjective contexts.

In 2023, [14] focused on assessing the ERP implementation readiness of several higher education institutions in Jordan. The readiness dimensions used are organizational context (competitive strategy, available resources, operational methods, sophistication of existing IT use, procurement methods), business process (operational, managerial, integration), perception of ERP (complexity, strategy, benefits strategic advantage, desire to implement) and external forces (business environment, commercial dependence). The author used two types of questionnaires (online and paper) to collect the data. The result obtained helped to classify these institutions in terms of high, medium and low adopters. The main limits of this method are related to the questionnaire that does not consider subjective contexts and the absence of solutions for readiness improvement.

2.3 Gap analysis

Most of the existing Erm methods best suit to wealthier contexts in terms of the budget, infrastructure and human resources required. Hence, they might be difficult to implement in poorer contexts such as those in Developing countries. They are also more suited to objective cultures, neglecting the effect of subjective ones, which are more prevalent in DCs. This opens a challenge to find a readiness management solution that can adapt to an organization's context. This is more challenging because contexts are not static and, there is no method that is suitable for all possible facets of the contextual variables. This conclusion is in line with the generalisability problem reported in [15,22].

Based on that analysis, the main challenge remains and the research question is how to define a solution to ERP readiness management that can adapt to the organization's context (economic, infrastructure, human knowledge, culture) in each aspect of its life-cycle?

3. METHODS

The present article uses Situational Method Engineering as a framework to approach the problem and follows the steps defined by the Design Science methodology to build a solution.

3.1 Situational Method Engineering (SME)

SME studies those methods that are able to adapt to the situation of the project at hand. The general principle is to reuse method parts, initially stored in a method base or repository, and to assemble them as a new method using a particular guideline. The most prominent approaches to SMEs are *fragments, OPF components, chunks, components and services* [26]. The choice was mainly based on the ease of use of the approach and its level of expressiveness. From this perspective, the SME approach based on chunks turns out to be the best.

The principle of SME based on chunks (A chunk is a process and the resulting product) is built around a method engineer whose goals are to decompose and assemble methods. Chunks are stored in a method base and created either by decomposing methods using a guide, or built from scratch depending on the need. Chunks comply to a metamodel and to build a new method, they are selected from the repository and assembled. The resulting method quality is evaluated and applied according to the requirement map. This approach could help to build adaptable ERM methods but comes with several weaknesses:

- There is a risk of bias in chunk assembly: The whole approach depends on the existence of a method engineer which might be difficult in contexts with less expertise, and at risks in corrupt or subjective contexts because of bias.
- There is no way to specify the organization's context that suits (Where) to a method: The existing chunk's metamodel focused on technical aspects in the Software engineering. Organizational aspects are not merely considered.
- There are no specifications of usage constraints (Who): Some contexts might have issues with human resources, but there is no ways to clarify the necessary conditions to use a particular chunk.

Those weaknesses represent the sub-objectives to tackle in this article. The requirement map for a context-aware ERM model is built iteratively and should respect the following signature: <*Organization’s context, Construct an ERM method*>; it must consider the situation of an organization with the intention to define the most appropriate ERM method. This map is constructed iteratively, and the final result is shown in the Figure 1.

The sections presented in this map are as follows:

- S1: <Start, Identify readiness dimensions, Dimensions identification strategy>
- S2: <Identify readiness dimensions, Define readiness dimensions, Data collection strategy>
- S3: < Define readiness dimensions, Analyze readiness data, Readiness Computation strategy>
- S4: <Analyze readiness data, Analyze readiness data, Satisfiability assessment strategy>
- S5: <Analyze readiness data, Define improvement plan, Improvement plan definition strategy>
- S6: <Define improvement plan, Define readiness dimensions, data collection strategy >
- S7: < Analyze readiness data, Stop, End of use >
- S8: < Define an improvement plan, Stop, End of use >

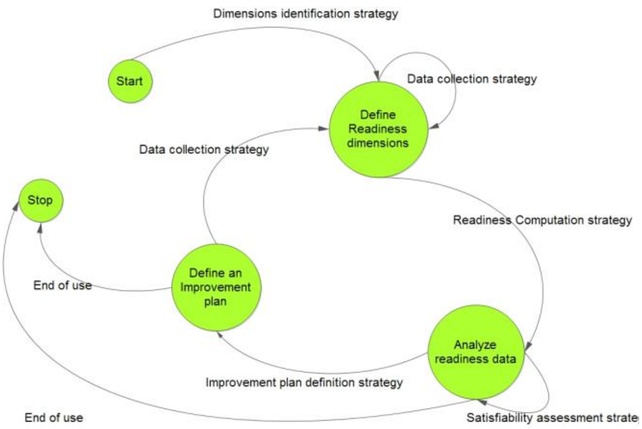

Fig 1: Requirement map for ERM method construction

The strategies and intentions set out in the requirements map are generic and reflect the essential elements of an ERM method, as outlined in the existing literature. The latter is used to define the method components or possible variants that will be used to construct an ERM method.

3.2 Design Science

The Design science steps established by [27] are followed. Having the main objective defined (situationalize ERP readiness Management), the next step in the methodology is to design, demonstrate and evaluate a solution as shown in Figure 2.

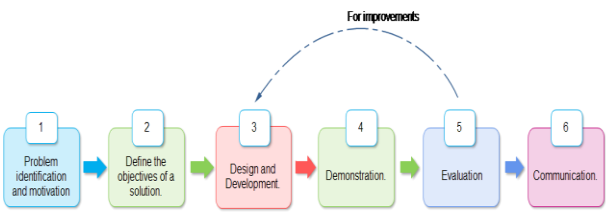

Fig 2: Design Science research of Peffers

3.2.1 The Design and demonstration processes

The goal here is to be able to build an ERM method based on ERM chunks stored in a repository. The expected solution is a situational model for ERM (SI-MERM); its architecture is presented in Figure 3.

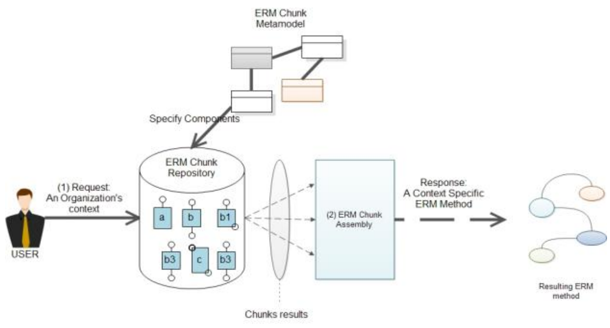

Fig 3: The Architecture of Si-MERM

The user's request is sent to a repository containing ERM chunks with specifications defined by an ERM chunk metamodel. The selected ERM chunks are assembled in an unbiased manner to create the required method, which is then evaluated and implemented. The main goal in the design process is to build an ERM chunk metamodel, a repository and an assembly technique.

Defining a Metamodel: To be able to specify the conditions under which an ERM chunk can be used (Who) and its most suitable organization’s context (Where), the chunk's metamodel of [28] is extended in its interface and in its descriptor. This is done with the help of UML and Boolean Logic.

Building ERM chunks Repository: The repository is the structure in which chunks are stored. It is built using graphs and implemented in XML. ERM chunks are extracted from the literature following a re-engineering strategy defined in [29]. Concretely, existing ERM methods are decomposed into ERM chunks with contextual properties.

Defining an unbiased chunk assembly process: To avoid bias in method assembly, a more formal assembly technique needs to be provided. For that purpose, an algorithm is defined.

3.2.2 The Design and demonstration processes

The resulting model is expected to be a merge of existing ERM methods and be able to derive a new method according to a specific context. In this process, experimentations are undertaken to assess the capacity of Si-MERM to derive existing ERM methods.

4. RESULTS

This section presents the SI-MERM model.

4.1 Erm chunk (EC) metamodel

An EC is defined as a type of **Chunk**, so it has the same properties and associations, meaning, it has a descriptor, an interface and a body. The concepts introduced are **Usage Constraint** (UC), and **Organization Context** as presented in the metamodel from the Figure 4.

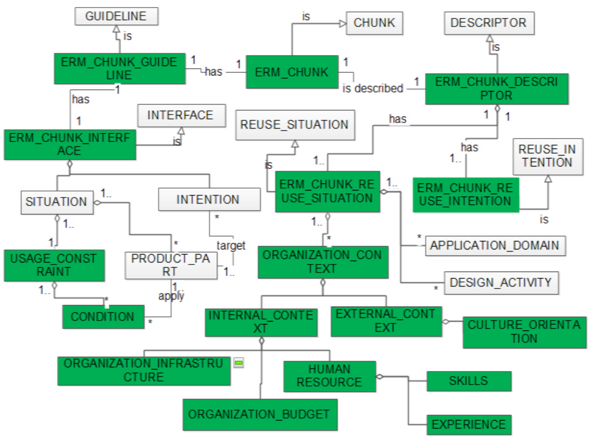

Fig 4: The Metamodel of an Erm chunk

A UC is defined at the *situation* of an EC and it consists of several conditions. A condition applies to several product parts. An EC can also apply to several organizational contexts. Its signature is defined by the following tuple : *<Situation = (Product Parts, Usage Constraints), Intention>*. In this tuple, the situation is represented by the product parts and a usage constraint formula (see in the following sections), both of which are useful for selecting and well applying the corresponding ERM chunk.

4.1.1 The Usage Constraint (UC) concept

A UC occurs within an EC and is used to clearly represent the conditions required for a component to be used effectively. This was not possible in the initial chunk's specification. For instance, a method may be limited by the knowledge of FANP (Fuzzy Analytic Network Process). The goal of UCs is to specify this kind of detail to the project team, enabling them to use the method effectively. The syntax and semantics of this concept are defined below.

Usage Constraints Formalization: A usage constraint is defined as a set of conditions logically linked within a formula; each condition is defined using the propositional logic. Its aim is not merely for computation but to share a common understanding. To help define such a formula, the following grammar is proposed:

$$Uc := C \mid (C) \mid C \text{ op } C$$

$$Op := \wedge \mid \vee$$

Where ∨ and ∧ are respectively OR and AND operators, and C $\in C_G$ (C_G is the set of conditions).

Syntax of the conditions: The syntax tells the chunk constructor how to represent a constraint. Consider the following constraint: Guideline I1 requires the project team to have literature review skills for the project to be executed well. So, there is a guideline that imposes a certain condition (the need for literature review skills) on a certain object (the project team). Therefore, a team member should have this profile for the guideline to be comfortably applied. Such a statement is represented using the OCL (Object Constraint Language: http://www.omg.org/spec/OCL/2.4). A condition is therefore a Boolean expression in which the attribute of an object is mapped to a particular value, which is also an object, as shown in the following:

$$C: Att_{Obj}(val) = \begin{cases} \textbf{True} \;\; If\ val\ is\ required\ by\ the\ guideline \\ \textbf{False} \;\; Otherwise \end{cases}$$

Another notation of this equation is *Obj.Att = val using OCL*. Considering the previous example, the following condition could be written: (1) *Project_Team.Skill = Literature_review*. This condition constraints the presence of literature review skills in the project team. The absence of a constraint might be sufficient to express the "negation" aspect of the property. But, depending on the case, it might be useful to negate it explicitly (by introducing the "not" expression before the value part).

4.1.2 The Organization Context

Another construct called **Organization Context** is introduced to characterize the most appropriate context for a particular Erm chunk. An organization context can be internal (*Internal Context*), i.e. related to situational variables within the organization, or external (*External Context*), i.e. related to situational variables outside the organization but with an impact on an ERP implementation project. The internal context includes economic (*organization budget*), human (*human resources*) and infrastructure (*organization infrastructure*) constructs; the human construct includes *skills* and *experience*. The external context reflects the national culture (*Culture Orientation*) that prevails in the organization. The other constructs (such as *Subjective, Highly Subjective, Objective, High Budget, Low Budget, Medium Budget, High Experience, Low Experience, Medium Experience*), which are part of the previously defined constructs, are also introduced.

4.1.3 Quality assessment

This section evaluates the quality of the proposed ERM chunk metamodel by showing how the new metamodel describes the concepts of the previous one. This demonstration is straightforward because the new model inherits the properties of the previous model without altering its structure or behavior. Rather, it improves upon them. As an ERM chunk inherits from a chunk, any component described by the latter's metamodel can also be described by the formers.

4.2 Designing ERM chunks and repository

In this section, ERM chunks are identified and built using a re-engineering strategy. The process starts with defining sections, then deriving guidelines from sections, and finally defining ERM chunks.

4.2.1 Sections definition

Here, the four main intentions defined in the previous requirement map (see Figure 1) are explored in depth: **Define readiness dimensions, collect data, Analyze readiness degree, Define an improvement plan**.

Define Readiness dimensions:

To achieve this, it should be possible to define strategies for identifying the readiness dimension and for collecting data.

Identify readiness Dimension: The chunk covering this intention should have the following signature: *<Start, Identify readiness dimensions following a Dimension identification strategy>*. The unknown element here is the strategy that could be adopted. For the domain expert who wants to define readiness dimensions, the literature offers three main ways: doing own research (S2.3), using existing dimensional models (S2.3a), deriving a dimensional model from the organization's requirements (S3.3). The organization may also decide to use FAHP to identify the weights of the relationships between dimensions (S3.3a). Using that, the sections identified are the following:

- S2.3: *<(I2)(Start, A Stakeholder with literature review skills), (I3)Define readiness dimensions, literature review strategy>*.
- S2.3a: *<(I2a)(Start, A Stakeholder with literature review and selection skills), (I3)Define readiness dimensions, Dimension reuse strategy>*.
- S3.3: *<(I3) Define readiness dimensions, (I3)Define readiness dimensions, Literature review strategy>*
- S3.3a: *<(I3) Define readiness dimensions, (I3) Define readiness dimensions, FAHP strategy>*

Collect Data for readiness dimensions: The section identified for this intention is S3.4: *< (I3) Define readiness dimensions, (I4) Collect dimensions data, Requirement elicitation strategy>*. Having a dimensional model of the organization, data on the dimensions needs to be collected. This data represents the current state of the organization, with the ability to influence future results. The signature is as follows: < **(dimensional model), Collect data using a data collection strategy**>. The unknown concept here is the data collection strategy to be used. Existing ERM proposals use elicitation techniques to collect data on dimensions, hence the section *S3.4*. The identified ones are questionnaires and focus groups.

Analyze readiness data:

The chunk covering this intention should respect the following signature: <**(dimensions state), Analyze readiness data using readiness computation strategy**>. In this step, the domain expert wants to have a precise idea of the readiness state of the organization before implementation. This is usually done by analyzing the readiness of each dimension and using these results to calculate the final readiness of the organization. However, the quality of the result obtained, its accuracy and the way it is achieved depends on the strategy followed. Several techniques have been used to satisfy the sub-intentions necessary to calculate the final level of readiness; they are resumed by the following sections:

- S3.6: *<(I3) Define readiness dimensions, (I6) Assess readiness level, FCM strategy>*
- S3.6a : *< (I3) Define readiness dimensions, (I6) Assess readiness level, FANP strategy>*
- S3.6b : *<(I3) Define readiness dimensions, (I6) Analyze readiness level, Fuzzy expert system strategy>*
- S4.5: *< (I4) Collect dimensions data, (I5) Compute dimension weights, AHP strategy>*
- S4.5a: *< (I4) Collect dimension data, (I5) Compute dimension weights, D-S combination strategy>*
- S4.5b: *< (I4) Collect dimension data, (I5) Compute dimension weights, CFA strategy>*
- S5.6: *<(I5) Compute dimension weights, (I6) Analyze the readiness level, Structured computation strategy>*
- S5.6a: *<(I5) Compute dimensions weights, (I6) Assess readiness level, Mean strategy>*
- S5.6b: *<(I5) Compute dimensions weights, (I6) Analyze readiness level, Worksheet strategy>*.
- S6.6: *<(I6) Analyze readiness level, (I6) Analyze readiness level, Satisfiability assessment strategy>*

Define improvement plan:

The signature for a chunk aimed at achieving this intention is *< (Organisation Readiness State), Define an Improvement Plan using Improvement Plan Definition Strategy>*. The sections identified for this intention are:

- S6.7: *<(I6) Analyze readiness data, (I7) Identify factors to improve, DEMATEL strategy>*,
- S7.8: *<(I7) Identify factors to improve, (I8) Define improvement plan, NSGA II strategy>*
- S8.3: *<(I8) Define improvement plan, (I3) Define Readiness dimensions, Selection strategy>*

In this step, the aim is to improve the current state in the organization: this can be done by identifying the factors to be improved and defining the most cost-effective improvement plan. Hence the sections *S6.7* and *S7.8*. After the improvement, the level of readiness could be reassessed with the section *S8.3*

4.2.2 Guidelines definition

Guidelines represent process execution. On the *Situation* aspect of each guideline, usability constraints are introduced where necessary. In this case the signature becomes < (Situation = Product Model, Use Constraint(Uc)), Intention>. Depending on the section, an IAG (Intention Achievement Guideline), ISG (Intention Selection Guideline) or SSG (Strategy Selection Guideline) is defined. The tables 2 and 3 list the identified sections and their associated guidelines.

Tableau 2: Sections and their associated IAG

Section	IAG	Section	IAG	Section	IAG
S2.3	IAG2.3	S2.3a	IAG2.3a	S3.3	IAG3.3
S3.3a	IAG3.3a	S3.4	IAG3.4	S3.6	IAG3.6
S3.6a	IAG3.6a	S3.6b	IAG3.6b	S4.5	IAG4.5
S4.5a	IAG4.5a	S4.5b	IAG4.5b	S5.6	IAG5.6
S5.6a	IAG5.6a	S5.6b	IAG5.6b	S6.6	IAG6.6
S6.7	IAG6.7	S7.8	IAG7.8	S8.3	IAG8.3

Tableau 3: Intentions and node pairs, with their associated ISG and SSG references

Intention	ISG	Node pairs	SSG
FromI3to(I3,I4or I6)	ISG3	I2,I3	SSG23
FromI6to(I6,I7or Stop)	ISG6	I3,I6	SSG36
FromI8to(I3orStop)	ISG8	I4,I5	SSG45
-	-	I5,I6	SSG56

Intention Achievement Guidelines:

IAG are guides useful to achieve a particular intention. This section details the execution of one guideline, while the other guidelines are detailed in the literature and not formally presented in the present article because of the words limit.

The IAG2.3-Literature review: The application of this guideline is limited by the skills required for literature reviews: *C2.3: Stakeholder.Skills = Literature review*. These skills should also be considered when forming the project team. The aim of this a review will be to identify the CSFs for an ERP implementation with their KPIs (Key Performance Indicators) and to group them into dimensions. As the importance of a factor may vary from one context to another, it may take a further try from the project team to finally have a dimensional model. The guideline signature is then *<(Start,C2.3), Define readiness dimensions following a literature review strategy>*

Strategy Selection Guidelines:

An SSG explains how to move from one intention to another in a multi-strategy approach. Just the SSG23 will be described in this article for the sake of space.

SSG23 - From Start to I3: The aim here is to choose a strategy between literature review (IAG2.3) and dimensional reuse

(IAG2.3a), to define readiness dimensions; hence the signature: *<(I2(Start): State(I2)=Completed),Progress to I3 (Define readiness dimensions)>*. For this case, a choice guideline is proposed and shown in the Figure 5. Two different alternatives are presented:

- **(a1)** is constrained by the existence of expertise in literature reviews; it is suitable when an organization needs to define its own dimensional model. This approach can be costly and time consuming and best suits for large or wealthy organizations.
- **(a2)** is constrained by the existence of knowledge both in literature review and selection techniques such as multi-criteria decision making. The aim is to have a set of dimensional models and choose one or more among them. This approach may be less time consuming and costly than the previous one, and therefore might best suit to small organizations.

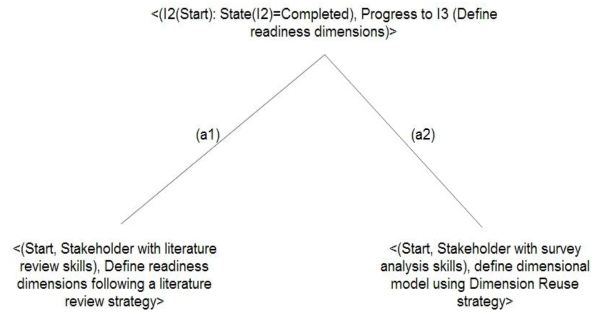

Fig 5: The The SSG23 guideline

Intention Selection Guidelines:
An ISG defines a guideline for getting from an intention to either an IAG or an SSG. An example is the ISG3, described in the following.

ISG3 - From I3: The Signature for this ISG is: <(Dimensions defined), Progress from I3 (Define readiness dimensions)>. At this point, the project team has defined the dimensions of readiness and is asking itself what its next intention is to continue in defining the dimensions of readiness (IAG3.3), to calculate the weights of the dimensions (IAG3.3a), to continue in collecting data (IAG3.4), or to move on to the analysis of readiness (SSG36). This choice guideline is illustrated by the figure 6.

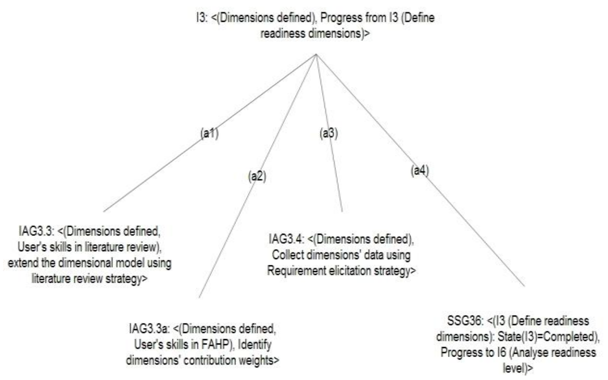

Fig 6: The The ISG3 guideline

4.2.3 Defining ERM chunks

The next step after defining guidelines is to define chunks. The strategy used to identify them is *section-based discovery*, where most sections are considered as potential independent methods. In these specifications, some values are given to chunks based on their capabilities or characteristics. For example, to categorize a chunk as subjective or objective, it is checked in its guideline whether it handles risks of uncertainty caused by the subjective source of data or the data itself.

The budget is defined on the basis of the extent of the expenditure required for the chunk to be applied; it can therefore be low, medium or high. Following this principle, 18 ERM chunks have been defined. As examples, the ERM Chunks 2.3 and 2.3a are presented in the following.

Erm_Chunk2.3: This chunk implements the section S2.3 and it is defined as follows:

The Signature: *<(Organization's context, Stakeholder.Skill = literature review), Define readiness dimensions>*

The Guideline: A simple guideline defined by IAG2.3

The Descriptor:

- Objective: Help the organization in defining its readiness dimensions
- Type : Atomic
- Reuse Situation
  - **Application Domain:** Information Systems
  - **Design Activity:** ERM / Dimensional model design
  - **Organization context**
    - **Internal**
      - **Human Resource :** Low level of skills and experience
      - **Organization's infrastructure :** Low level
      - **Organization's Budget :** low level
    - **External**
      - **Culture Orientation :** Objective
- Reuse Intention: Define readiness dimensions following a literature review strategy.

Erm_Chunk2.3a: This chunk implements the section S2.3a and it is defined as follows:

The Signature: <*(Organization's context, Stakeholder.Skill = Literature review and Selection techniques), Define readiness dimensions >*

The Guideline: A simple guideline defined by IAG2.3a

The Descriptor:

- Objective: Help the organization in defining its readiness dimensions
- Type : Atomic
- Reuse Situation
  - **Application Domain:** Information Systems
  - **Design Activity:** ERM / Dimensional model design
  - **Organization context**
    - **Internal**
      - **Human Resource :** Low level of skills and experience
      - **Organization's infrastructure :** Low level
      - **Organization's Budget :** low level
    - **External**
      - **Culture Orientation :** Objective
- Reuse Intention: Define readiness dimensions following a survey strategy.

Si-MERM is modeled as a directed multigraph *G = {V, E}*, where vertices (*V*) are intentions and edges (*E*) are ERM chunks. The model is shown in the Figure 7 (Ec is an abbreviation of ERM chunk in the figure).

The next section focuses on how to use Si-MERM to construct an ERM methodology based on the organization's context.

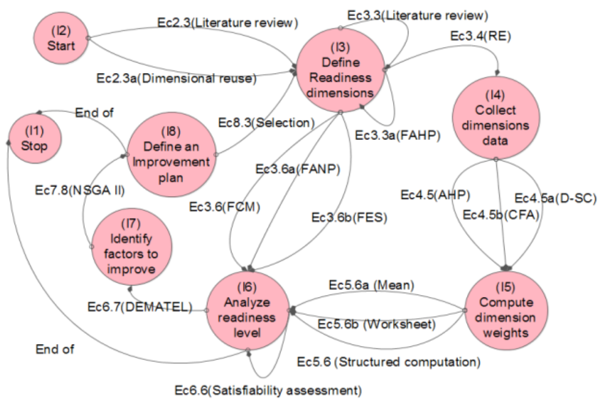

Fig 7: The Si-MERM Model

4.3 The Method design process

This section explains how to move from an organization context to an ERM method. A formal way to derive the most suitable method is described in what follows.

4.3.1 The problem with a method Engineer

Having a repository of ERM chunks, the goal of the method engineer is to assemble chunks according to the needs. But, the more chunks we have, the more time it takes the method engineer to build the needed method, and higher are risks bias.

4.3.2 An algorithm to assemble ERM chunks

This section presents the algorithm for ERM chunks assembling.

General principles: To avoid the previous gaps, an algorithm is built on top of the Dijkstra algorithm for short path identification in a graph. This algorithm works well on positively weighted digraphs and it is one of the most popular algorithms for solving the shortest path problem with a time complexity of $\mathbf{O}(n^2)$ [30]. To use it, two problems remain: (1) every edge(in this case, chunks) in the graph must be weighted using some notion of distance or length; and (2) there should be only one edge between two nodes. Therefore, the unweighted graph of the repository needs to be transformed into a weighted digraph. The second (2) problem is solved by choosing the shortest distant edge. The next section suggests a way to define the weights.

The graph transformation process: Finding the shortest path is equivalent to discovering the most appropriate ERM method going from the *start* to the *stop* node. Dijkstra goes through the graph to find the shortest path, but what is needed in this case is to find the most appropriate ERM method. To compute distances (or weights), the organization's state of an attribute (Att_{state}) is compared to its equivalent in the requirements (Att_{req}) of the chunk. The aim is to evaluate the organization's ability to fulfill the requirements of the chunk. This process is illustrated in the pseudo-code below:

- For each attribute *Att* in a chunk:
  1. ***if*** Att_{state}= Att_{req} *then* $d_{Att}(state, req) = 0$: There is no distance if the organisation's state is the same as the requirement in a chunk.
  2. ***else if*** $Att_{state} > Att_{req}$ then $d_{Att}\,(state, req) = 0$: if the state includes the requirement.
  3. ***else*** $d_{Att}(state, req) = 1$: If the state cannot fulfil the requirements, the distance is 1.
- Compute the final distance

The values 0 and 1 are symbolic and do not reflect an effective distance, in term of a gap for example, but are mainly introduced to facilitate the calculation process. In this process, attributes are considered to have the same importance. At the end of this process, the total distance (*D*) is defined by adding computed distances, when all attributes are required; or by multiplying them when a choice needs to be done:

$$D = \begin{cases} \sum d_{Att} \;\; \textit{If each attribute is required} \\ \prod d_{Att} \;\; \textit{Otherwise} \end{cases}$$

Having the distances, Dijkstra's algorithm can then be applied. At the end of the process, the shortest path obtained between the nodes *start* and *stop* is identified and considered as the desired method. The resulting method can then be reviewed by the project team to assess their ability to apply it. When ERM chunks from the same section have the same distance, the most suitable one is chosen based on the usage constraint property.

Example: Consider an ERM chunk requirement, with the context of an organization described in the table 4:

Tableau 4: Example of data used to compute the distance

Distance	Attributes	Chunk24	Organization's state
d_1	Objects	R_1:set of stakeholders	N_1:can afford stakeholders
d_2	Usage constraints	R_2: $((C_1 \land C_{16}) \lor C_2) \land (C_3 \lor C_4 \lor C_5 \lor C_6)$	N_2: Just C_1, C_{16}, C_3, C_6 are valid
d_3	Application domain	R_3:Information Systems	N_3:itisanISproject
d_4	Design activity	R_4:Requirement Engineering	N_4: It will be used for Knowledge management

The aim is to calculate the final distance of the chunk according to the organization's needs: $d_{Chunk} = d_1 + d_2 + d_3 + d_4$. Each d_i is obtained by comparing chunk's values to the organization's state.

- $R_1 = N_1$, because the chunk requires the existence of a group of stakeholders that the organization can afford, according to the method constructor (the user). Therefore d_1 = 0;
- With usage conditions, the evaluation is related to each condition by considering the different operators, such that $d_2 = \big((d_{C1} + d_{C16}) * d_{C2}\big) + (d_{C3} * d_{C4} * d_{C5} * d_{C6}) = \big((0 + 0) * 1\big) + (0 * 1 * 1 * 0) = 0$. The value obtained indicates that, given the conditions, the guide is suitable for the user's needs;
- $d_3 = 0$ because the chunk will be used in an IS project;
- $d_4 = 0$ because knowledge management is not the same as requirement engineering.

At the end, the final result is d_{Erm_Chunk} = 1; this data is used in the next stage of the process to calculate the shortest path or most appropriate method.

5. EVALUATION

In order to demonstrate the capability of the model proposed to effectively describe existing methods, experimentations are undertaken in a brute force analysis because of the limited number of ERM methods in the literature.

5.1 Describing the model of [21]

In this model, the readiness dimension is predefined and can therefore be obtained using either ERM chunks 2.3(Literature review) or 2.3a (Dimension reuse). Using that, the FANP is applied. Hence the path presented in the Figure 8 shows the ability of the model to describe this method.

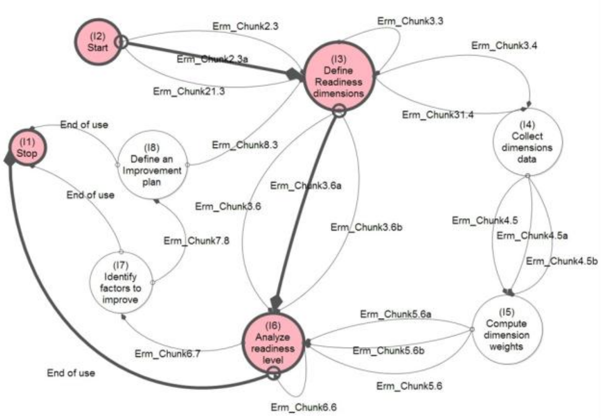

Fig 8: Assessment of Si-MERM compared to the model of [21]

5.2 Describing the model of [22]

The process needed to execute this method corresponds the following path: 2.3a (Dimension reuse) – 3.4(Requirement elicitation) – 4.5b (CFA) – 5.6a(Mean computation) – "End of use". It is presented in the Figure 9.

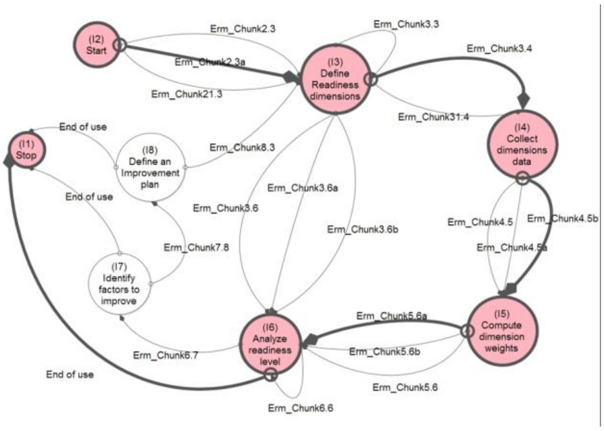

Fig 9: Assessment of Si-MERM compared to the model of [22]

5.3 Describing the model of [15]

The Kirmizi method follows a process in which a literature review is done (ERM_chunk 2.3), next data is collected using ERM_chunk 3.4, next AHP is combined into a computational strategy (ERM_chunks 4.5 and 5.6) to finally compute the readiness. The path is shown in the figure 10.

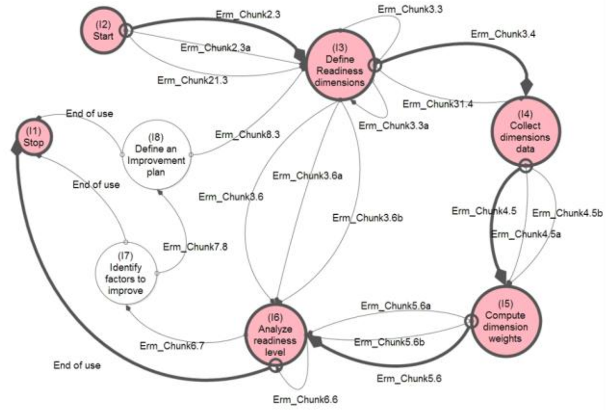

Fig 10: Assessment of Si-MERM compared to the model of [15]

6. DISCUSSION AND CONCLUSION

In this article, a solution based on SME has been proposed to define an ERM method depending on a set of situational factors identified, such as the required products, the usage constraints and, the reuse situations and intentions. The contextual variables are economy, culture, infrastructure and human resource. The result obtained therefore helps to achieve the following:

1. To build an ERM method based on a set of ERM chunks and their suitability to a particular context. With this new approach, professionals are able to build methods according to their suitability to their contexts, and researchers can now give more attention in building components with respect to specific context variables to extend the Si-MERM model.
2. New properties have been introduced to chunk metamodel, improving its expressiveness in terms of how the component could be used (*Usage Constraints* introduced in the interface) and in which context (*Organisational Context* introduced in the reuse situation).
3. An algorithm that assembles ERM chunks according to contextual variables is introduced to reduce manual effects and errors in the process.

The experiments conducted helped to demonstrate the model's ability to describe existing ERM methods, hence proving the usefulness of combining SME and ERM to solve an issue in the ERP literature. Compared to existing ERM models, the proposed model combines existing ERM properties and offers ways to extend and sustain them in a modular manner. It offers a framework for future research in the domain towards a situational ERP implementation. This study highlights the power of combining ERM and SME with a result that is the first of the kind to the best of the authors' knowledge. The main limit of this study is the evaluation process. It shows the capacities of the model in describing existing ones, but needs more case studies to assess its impact in practice, and improve theories on ERP implementation failure. It also needs to be extended with more context-specific Erm chunks to be able to define readiness dimensions according to the organisation's context and to collect data on them when the context is subjective. Extending the model with more context variables and to the ERP implementation life-cycle, including phases like Erp selection, Erp alignment, data quality management, Erp learning is put on perspectives.

7. REFERENCES

[1] Ibrahim, Muhammad Faisal, Y. S. D. N. N. M. I. M. and Utama, D. M. 2024. A literature review on ERP implementation: Methodologies, module, software, and policy. In *In AIP Conference Proceedings*, volume 2927, pages 1–6. AIP Publishing.

[2] Coskun, Evren, B. G. M. A. A. K. T. and Garousi, V. 2022. ERP failure: A systematic mapping of the literature. *Data & Knowledge Engineering*, 142 (102090).

[3] Manga, T. A., Atsa Etoundi, R., and Zoa, J. 2016. A Literature Review of ERP implementation in African countries. *EJISDC*, 76(4):1–20.

[4] Atsa Etoundi, R., Manga, T. A., and Mvoa Onana, B. S. 2016. Using ICT in controlling staff and payroll in the cameroonian public service: Lessons learned and perspectives. *EJISDC*, 76(1):1–18.

[5] Vargas, M. A. and Comuzzi, M. 2020. A multi-dimensional model of Enterprise Resource Planning critical success factors. *Enterprise Information Systems*, 14(1):38–57.

[6] Bitsini, N. (2015). Investigating ERP Misalignment between ERP Systems and Implementing Organizations in Developing Countries. *Journal of Enterprise Resource Planning Studies*, 2015:1

[7] Bramantyo, B., Halim, E., Arring, S. O. A., and Sukmaningsih, D. W. 2024. Enhancing Readiness: A Comprehensive Study on ERP Implementation Readiness Factors. In *2024 International Conference on Information Management and Technology (ICIMTech)*, pages 1–6.

[8] Wright, D. R. 2023. User Training and Change Management Synergy: Keys to ERP Success in SMEs. *Frontiers in Management Science*, 2(6):38–46

[9] Sun, H., Ni, W., Lam, R., and Ng, C. Y. 2016. A Stage-by-Stage Assessment of Enterprise Resource Planning Implementation: An Empirical Study from Hong Kong. *Journal of Global Information Technology Management*, 19(2):104–127.

[10] Kirmizi, M. and Kocaoglu, B. 2022. The influencing factors of enterprise resource planning (ERP) readiness stage on enterprise resource planning project success: a project manager's perspective. *Kybernetes*, 51(3):1089–1113.

[11] Harun, A. and Mansor, Z. 2019. Individual Readiness for Change in the Pre-Implementation Phase of Campus Enterprise Resource Planning (ERP) Project in Malaysian Public University. *International Journal of Advanced Computer Science and Applications (IJACSA)*, 10(1)

[12] Tekleselassie, R., Lessa, L., and Negash, S. 2021. ERP PreImplementation Readiness Assessment Framework: A Multi Stakeholders' Perspective. In *The 7th Annual African Conference on Information Systems and Technology Preceedings*.

[13] Afiana, F., Septiana, L. N., Khotimah, K., and others 2022. Technology Readiness Index (TRI) for Measurement of User Readiness in ERP Implementation in the Marketing Department. *Jurnal Sistem Informasi dan Ilmu Komputer Prima (JUSIKOM PRIMA)*, 6(1):35–42.

[14] Althunibat, A. 2023. Assessing the Readiness of Jordanian Universities for Implementing Enterprise Resource Planning (ERP) Systems: A Case Study. In *2023 International Conference on Digital Age & Technological Advances for Sustainable Development(ICDATA)*, pages 24–27. IEEE.

[15] Kirmizi, M. and Kocaoglu, B. 2020. The key for success in enterprise information systems projects: development of a novel ERP readiness assessment method and a case study. *Enterprise Information Systems*, 14(1):1–37

[16] Ahmadi, S., Yeh, C.-H., Martin, R., and Papageorgiou, E. 2014. Optimizing ERP readiness improvements under budgetary constraints. *Int. J. Production Economic.*

[17] Mueller, S. K., Mendling, J., and Bernroider, E. W. 2019. The roles of social identity and dynamic salient group formations for ERP program management success in a postmerger context. *Information systems journal*, 29(3):609–640

[18] Manga, T. A. and Atsa Etoundi, R. 2017. An AHP Algorithm for an effective ERP type selection based on the African context. *EJISDC*, 83(5):1–17.

[19] Iacovelli, A. and Souveyet, C. 2008. Framework for Agile Methods Classification. In *MoDISE-EUS*, pages 91–102.

[20] Hofstede, G. J. and Minkov, M. 2010. *Cultures and Organizations: Software of the Mind (Rev. 3 rd ed.)*. New York: McGraw-Hill.

[21] Razmi, J., Sangari, M. S., and Ghodsi, R. 2009. Developing a practical framework for ERP readiness assessment using fuzzy analytic network process. *Advances in Engineering Software*, 40(11):1168–1178.

[22] Hanafizadeh, P. and Ravasan, A. Z. 2011. A McKinsey 7S Model-Based Framework for ERP Readiness Assessment. *International Journal of Enterprise Information Systems*, 7(4):23–63.

[23] Hidayanto, A., Hasibuan, M., Handayani, P., and Sucahyo, Y. 2013. Framework for measuring ERP implementation readiness in small and medium enterprise (SME): a case study in software developer company. *Journal of Computers*, 8:1777–1782.

[24] Ahmadi, S., Yeh, C.-H., Papageorgiou, E. I., and Martin, R. 2015. An FCM-FAHP approach for managing readiness-relevant activities for ERP implementation. *Computers & Industrial Engineering*, 88:501–517.

[25] Ahmadi, S., Papageorgiou, E., Yeh, C.-H., and Martin, R. 2015. Managing readiness-relevant activities for the organizational dimension of ERP implementation. *Computers in Industry*, 2015(68):89–104

[26] Henderson-Sellers, B., Ralyté, J., Agerfalk, P. J., and Rossi, M. 2014. *Situational Method Engineering*. Springer-Verlag Berlin Heidelberg 2014.

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

[28] Ralyté, J. 2013. Situational Method Engineering in Practice: A Case Study in a Small Enterprise. In Deneckère, R. and Proper, H. A., editors, *Proceedings of the CAiSE'13 Forum at the 25th International Conference on Advanced Information Systems Engineering (CAiSE), Valencia, Spain, June 20th, 2013*, volume 998 of *{CEUR} Workshop Proceedings*, pages 17–24. CEUR-WS.org.

[29] Ralyté, J. and Rolland, C. 2001. An approach for method reengineering. In Kunii, H., Jajodia, S., and Solvberg, A., editors, *20th International Conference on Conceptual Modeling, ER2001,*, pages pp. 471–484, Yokohama, Japan. Springer-Verlag Berlin Heidelberg 2001.

[30] Madkour, A., Aref, W. G., Rehman, F. U., Rahman, M. A., and Basalamah, S. 2017. A Survey of Shortest-Path Algorithms. *arXiv preprint arXiv:1705/02044*