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A MATURITY MODEL FOR INFORMATION SYSTEMS ACTION-RESEARCH PROJECT MANAGEMENT

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ABSTRACT

Action-Research is a research method broadly used in Information Systems. However, it requires improving its rigor and quality. To address this situation, several proposals have appeared, that give relevance to use Information Systems Action-Research through a vision of project management. This work is based on this vision by presenting a CMM-based maturity model to apply the project management practices in an incremental way with the aim of guaranteeing an improvement of the rigor and quality in Information Systems Action-Research projects.

1.   INTRODUCTION

Action Research is a research method the essence of which is the juxtaposition of action and research, or practice and theory, through the cyclic execution of four characteristic phases: planning, action, observation, reflection, where the last includes sub-phases for Evaluating and Specifying Learning (Susman and Evered, 1978). Action-Research is a potent research method for Information Systems research ([ITP, 2001], [Myers, 1997]). Nevertheless, Action-Research requires to improve the rigor and quality in its research process ([Avison et al, 1999], [Avison et al, 2001], [McKay and Marshall, 2000]) in order to increase its relevance within Information Systems research ([Applegate, 1999]).

To address this situation, [Mathiassen, 1998] proposed to use a perspective of projects and of project management approach to help to conduct Action-Research projects, while [McKay and Marshall, 2000] have proposed quality and rigor criteria for Information Systems Action-Research (IS-AR).

From the project perspective, [Estay and Pastor, 2000a] have proposed to use project management to improve the rigor of an IS-AR project by relating and mapping project management stages with Action-Research phases; [McKay and Marshall, 2001] and [Estay and Pastor, 2000b], [Estay and Pastor, 2000c] have proposed a project structure for IS-AR composed by two characteristic cycles: one problem solving-oriented construction cycle (C_{PSC}) and one research-oriented management cycle (C_{RM}); and [Avison et al., 2001] have analysed three aspects of control of an IS-AR project: initiation, determination of the authority, and degree of formalisation.

With regard to the project management approach, [Estay and Pastor, 2001b] have proposed a methodology to obtain IS-AR project management good practices. Such practices are mainly taken

and adapted from the PMBOK, the Guide to the Project Management Body of Knowledge ([PMI, 2000]), a document where the international organism Project Management Institute has compiled generally-accepted project management practices. Nevertheless, the application of these practices for IS-AR involves getting competence levels for project management and proficiency levels for Action-Research.

In particular, the proposal of Estay and Pastor could be characterised as the construction of an IS-AR project by focusing on the project management dimension. Along this line, we use the Blasco's project systemic theory (as explained in [Estay and Blasco, 2000]), which is based in a systemic and semiotic vision on the construction of the knowledge ([Estay, 2001]), itself based in Maturana's point of view about this issue ([Maturana, 1991]). In metaphorical terms, as in [Bryant, 2000], rather than viewing project management wrt. IS-AR as "a ruler to measure the beauty of a flower", we regard it as a source of practical knowledge and capabilities for improving the "cultivation" inherent to IS-AR research, as "good fertiliser for growing its flowers more beautiful and healthy." We aim at supporting and improving the art of IS-AR *gardening* rather than the *craft* of IS-AR engineering.

Thus, this paper follows Estay and Pastor's results by extending their work, from the IS-AR project towards a maturity model for IS-AR project management practices. In this sense, we relate the proficiency levels for Action-Research with the competence levels of project management maturity models through project management practices by following the software Capability Maturity Model (CMM). From this relationship we obtain five IS-AR maturity levels: novice, basic, organised, managed and adaptive. For these levels, we deploy our proposed IS-AR project management good practices. In this process we use Bloom's taxonomy ([Bloom, 1975]) as framework and Ramírez et al.'s educational congruence model ([Ramírez et al., 1988]) to define IS-AR maturity levels and leverage IS-AR practices with respect to the IS-AR maturity levels. The maturity model presented in this paper has been validated retrospectively in [Estay and Pastor, 2001a], while in [Guerrero, 2001] it has been applied in levels 2 and 3 by focusing on the practical dimension, which theoretical exposition appear in [Estay and Pastor, 2002].

The document is organised in the following sections. Section 2 presents CMM and the competence levels in project management. Section 3 introduces the proficiency levels in Action-Research. Section 4 develops our maturity model. Finally, Section 5 presents our final comments about the work realised and the future work.

2. PROJECT MANAGEMENT COMPETENCE LEVELS

From the area of projects, project management practices must be used according to competence levels. In this sense several maturity models for project management have been presented by taking as reference the software development Capability Maturity Model.

2.1. Software development Capability Maturity Model

The Software Engineering Institute's Capability Maturity Model ([CMM-SEI, 2000]) describes the principles and practices underlying software process maturity and it is intended to help software organisations improve the maturity of their software processes in terms of an evolutionary path from ad-hoc, chaotic processes to mature, disciplined software processes ([Paulk et al., 1985]). The CMM is organised into five maturity levels which are often used as synonymous with software engineering quality levels in many organisations. It is based on the assumption that organisation software engineering process maturity can be assessed against a standard. The CMM is that standard. The goals of the CMM are improved software quality, reduced software development cost, and decreased time to delivery of engineered software products. Its five levels are ([CMM-SEI, 2000]): initial, repeatable, defined, managed and optimising. In particular, each maturity level indicates an acquisition process

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capability and has several Key Process Areas (KPAs). Each KPA has goals and common features and organisational practices intended to institutionalise common practice.

2.2. Project management maturity models

A Project Management Maturity Model is a multidimensional model that spells out the meanings of, and the steps necessary to achieve specific project management competence. From the project management area the most cited project management maturity models are: Trillium model, Project Management Assessment 2000, Project Management Maturity Model and Innovation Maturity Model.

Trillium model. The Trillium Model is based on the Software Engineering Institute (SEI) Capability Maturity Model (CMM) version 1.1.The goal of this model is to provide a means to initiate and guide a continuous improvement program. The model is used in a variety of ways: to benchmark an organisation's product development and support process capability against best practices in the industry, in self-assessment mode, to help identify opportunities for improvement within a product development organisation, and in pre-contractual negotiations, to assist in selecting a supplier ([Trillium, 2000]). The architecture of the Trillium Model differs from the CMM version 1.1.

The Trillium scale spans levels 1 through 5: unstructured, repeatable and project oriented, defined and process oriented, managed and integrated, and fully integrated. The Trillium Model consists of Capability Areas, Roadmaps and Practices. There are 8 Capability Areas within the Trillium model. Each Capability Area contains practices at multiple Trillium levels. For example, Management spans levels 2 to 4 while Quality System spans levels 2 to 5. Each Capability Area incorporates one or more roadmaps. A roadmap is a set of related practices that focus on an organisational area or need, or a specific element within the product development process. Each roadmap represents a significant capability for a software development organisation.

Project Management Assessment. Project Management Assessment 2000 ([PMA, 2000], [Lubianiker, 2000]) is a holistic methodology and a software tool for the improvement of management processes in an environment of project management. It offers to give solutions to problems of inflexibility, of time, of not knowing how to make, and of lack of an incremental improvement. It is based on a model where generic and specific practices are integrated.

Management Maturity Model. Management Maturity Model ([PM3, 2000]) is oriented to project management practices. The model has been built from questionnaires to organisations that have successfully undertaking many projects, looking for and trying to define the best project management practices that they applied. The last version available of the model includes 300 lessons to be used at a corporate level.

Innovation Maturity Model. Innovation Maturity Model ([IMM, 2000]) is a proposal of product development. It is a vision on five innovation levels: Superficial, Feature Enhancements, Solution Enhancements, Breakthrough, and Disruptive.

2.3. Implementation of the maturity models

The previous models measure or provide guidelines to reach a certain competence level in project management. However, getting this competence requires more precision about the necessary maturity levels and the way towards their accomplishment.

With regard to the quantity of levels, we can reference ([Peterson, 2000]). He provides a PMBOK-based maturity model of 8 maturity levels to get a gradual competence in three dimensions: people, process and tools. Such levels are: Non-awareness, Initial, Basic, Repeatable, Advanced, Well-defined, Managed, and Optimising.

With regard to the accomplishment of the competence, ([White, 2000]) points out that a way to introduce project management practices that satisfy the maturity levels by following the CMM is by

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following iterative cycles. In this sense, ([White, 2000]) proposes a mechanism to try to sensitise the managers in the convenience of the learning necessary to improve. In this sense, White proposes the gradual development of the competence in project management through improvement cycles: a first cycle named "As-Is" documentation, a second cycle oriented to get a level 2 of maturity with processes and infrastructures updated, and then a third cycle to get a level 3 of maturity.

3.   ACTION-RESEARCH PROFICIENCY LEVELS

According to ([Greenwood and Morten, 1998]), Lewin has run several PhD programs for graduate students to practice Action-Research. The idea in this training is to combine theoretical knowing with practical skills in knowing how. The way to achieve this has been to have students work with experienced researchers. Thus, the professor-student dyads are combined in a group structure that creates a community of action researchers co-learning and developing skills together. Such relationships are more complex that a master-apprentice dyad.

The achievement of these networks requires fives stages of development of abilities, which are considered an important component in the achievement of a good action researcher. Such stages are ([Grenwood and Morten, 1998, p. 103)]: (i) Novice action-researchers follow analytical rules applied without much recognition of context and, like the orthodox researcher, feel detached from the process; (ii) Advanced beginners have the ability to read a context and to understand possible implications for actions; (iii) Competent action-researchers have the ability to shift between context-free and contextual components in a particular intervened situation, but her or his involvement in the activity is limited to trying to influence the outcome; (iv) Proficient action-researchers are involved in the situation, but with suggestions that include a strong theoretical content more than experiential one; and, (v) Expert action-researchers play a full involvement in the local situation and make many suggestions on the basis of experientially-informed intuitions about reasonable options drawn from previous experiences. These proficiency levels in Action-Research result from the learning that the researcher undergoes, a learning that includes theoretical domains and maturity in abilities.

4.   IS-AR MATURITY MODEL

We view our maturity model as a framework to implement IS-AR project management practices as part of IS-AR projects. In this sense, we first unify competence with proficiency and, second, we leverage project management practices inside the maturity levels. The process is depicted in Figure 1.
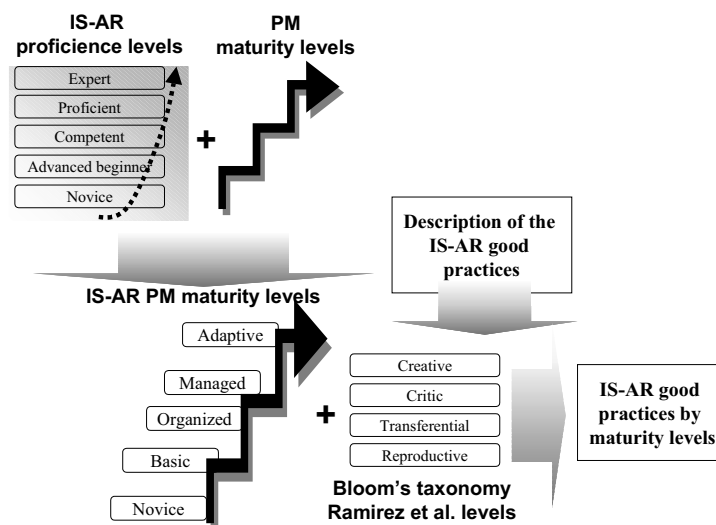

Figure 1

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4.1.   IS-AR project management maturity levels

From what we have stated above, now we have:

- competence levels that inform about the management capabilities to get through project management maturity levels; and,

- proficiency levels about the basic abilities that an action-researcher should possess.

Thus, we relate the proficiency levels for Action Research as given by ([Grenwood and Morten, 1998]), with the suggested competence levels for project management exposed in several project management maturity models ([Trillium, 2000], [PMA, 2000], [White, 2000]). Thus, we initially obtain a proposal for five maturity levels: novice, basic, organised, managed and adaptive.

Maturity models may not only help with the achievement of capabilities and the awareness of the importance of improvement but at same time, they help promote project management practices that provide quality and rigor to IS-AR projects. This interiorisation may be considered as a learning process which can be studied and applied with the helps of Bloom's taxonomy.

Benjamin S. Bloom proposes a taxonomy of educational objectives. Its purpose is to propose the foundations for a classification of the goals to get in an educational system. The taxonomy or classification proposed by Bloom embraces three areas or domains: cognitive area, affective area, and psycomotrice area, each one decomposed in formative goals ([Bloom, 1975]). Although the taxonomy is an important reference in Education research and practice, its application has proven difficult as shown by the fact that only the cognitive area is the most broadly treated one.

To facilitate the attainment of these domain goals, they are linked to educational objectives. In this way, for example, ([Gardiner, 2000]) offers a series of educational objectives for each one of the goals. These educational objectives are simply cognitive verbs, actions or operations, named educational verbs.

However, a more complete application of Bloom's taxonomy is proposed in ([Ramírez et al., 1988]). This model integrates Bloom's taxonomy, educational verbs and educational tools/techniques. In this sense, they propose that the educational verbs can be grouped into four types of educational objectives or formative levels (Table 1, [Ramírez et al, 1988]):

- *Reproductive*. Students must be able to retain and to assimilate, completely, scientific or technical knowledge, a favourable disposition toward a certain value, or a familiarisation with a psychomotor ability.

- *Transferential*. This level constitutes the practical phase of the learning; here the student uses previous knowledge.

- *Critical*. In this level, it is demanded to the student to compare the theory with the practice, the law with the case, the regulation with the facts; the ideal with the reality.

- *Creative*. In this level, the students are pursued to exploit their creative capacity to invent and to design.

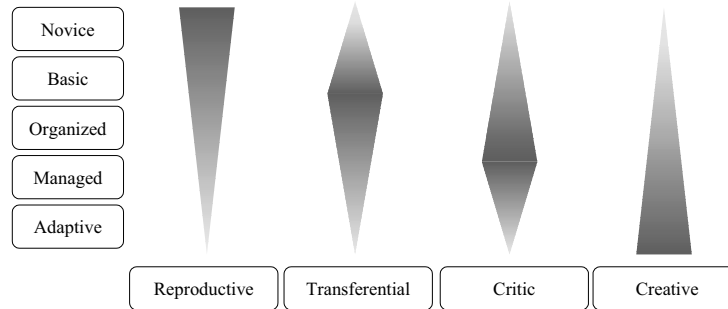| *Formative level*	*Educational verb*
Reproductive	Describe, name, repeat, cite, relate
Transferential	Employ, utilise
Critic	Examine, compare, research, test
Creative	Design, plan

Table 1

Figure 2

For our specific IS-AR purposes, the above formative levels imply a formative process from simple to more complicated actions. Seen in this way, the maturity levels can be related with the formative levels just as shown in Figure 2. The relationship pursues that the formative levels are applied with different intensity in each of the maturity levels: initially by giving higher intensity in getting reproductive objectives so that the action researcher learns on IS-AR; and, at the end, by giving higher intensity to creative objectives to promote the creative use by the action-researcher of the practices learned.

Thus, the IS-AR project management maturity levels can be characterised as follows:

- *Level 1. Novice.* This level is characterised by a general knowledge, principally literary, of Action-Research, reflected in the reproduction of actions. The success depends mainly on the innate characteristics of the novice researchers of what they understand for IS-AR, of the facilities contributed by the practitioners, and of luck.

- *Level 2. Basic.* The success of the process is obtained by following basic criteria that allows justifying the use of Action-Research. Elements of planning are introduced, trying to put emphasis in the scheduling. Moreover, the concept of product is introduced and the diffusion of results is regular to provide feedback. In this level it is attempted, in one or another way, to provide a level of understanding on the project concept, such that allows the execution of basic or initials good practices.

- *Level 3. Organised.* Project management practices are fully introduced through the institutionalising of aspects as the documentation of the process, the selection of the work team and the diffusion of results. The central idea is that the researcher is competent in the integrated application of advanced project management practices. Here it is important to acquire and use abilities of documentation that reflect all the aspects of research, improvement and learning.

- *Level 4. Managed.* Risk and quality project management processes are added with profusion. Also monitoring is started. The purpose is that the researcher acquires an integral vision of the undertaken management. It is pursued to reach a critical sense of the use of IS-AR in order to offer appropriate intervention proposals to the practical cycles. The researcher is proficient in the application and selection of practices in a precise and experienced way to create a coherent and appropriate set of project management practices.

- *Level 5. Adaptive.* This level institutionalises project management across the IS-AR project and along time. Expert, continuous, sometimes automated, creative and sustainable use of the results and experience are accumulated. Thus the action researcher evolves, learns and adapts her/his experience through learning and conversations with other researchers and practitioners.

4.2. Architecture of the model

The architecture of our IS-AR project management maturity model is the relational structure that allows going from a maturity level to its relevant good management practices. In this process we have followed the spirit of the Trillium model for the following reasons.

- While in CMM each maturity level is composed by specific practices, Trillium possesses roadmaps composed by practices applied in several maturity levels. In this sense, the acquisition of management capabilities should be taken one level at a time, first with simple practices (or partial practices) that then lead to other more complex, more advanced or more complete ones. This is conceptually and philosophically coherent with the idea of improving the project management of IS-AR, because it allows its assimilation and interiorisation gradually level by level, and because it allows the researchers to produce results from the first levels of maturity with simple practices.

- The Trillium architecture based on roadmaps, rather than key process areas, provides a product perspective, where the practices are not rules to follow, but suggestions to obtain good quality. For IS-AR, this means to introduce practices in participants or, in other words, to introduce the researchers to project management practices focused and guided by quality and rigor criteria.

Thus, by following the Trillium model, the architecture consists of the following elements: Roadmaps, Areas of Key interest and Practices.

Roadmaps. We have derived our roadmaps from the quality and rigor criteria for IS-AR proposed by [McKay and Marshall, 2000]. Each one of the criteria is related to several project management processes taken and adapted from the PMBOK.

- For example, the criteria "Practitioners should verify the work" related with the "Credibility of the research" can be focused with project management processes from the PMBOK: *Project Plan Execution* (4.2), *Overall Change Control* (4.3), *Scope Planning* (5.2), *Scope Verification* (5.4), *Scope Change Control* (5.5), *Performance Reporting* (10.3) and *Administrative Closure* (10.4). Thus, the verification can be reached and guaranteed with inspections in each one of these processes with the presence of practitioners.

With this, each roadmap relates with one or more maturity levels. This results from the analysis of the verbal contents of each criteria with respect to the formative levels.

- For example, with regard to the criteria "Practitioners should verify the work" related with the "Credibility of the research", this is a multilevel roadmap associated with the Organised and Managed maturity levels, because the verb *verify* is: part of the critical formative level, according to [Ramírez et al., 1987], and a transferential objective because it implies domain and communicational abilities to verify the work.

Thus, each criteria contains project management processes where can be integrated practices, and is related with one or more maturity levels to leverage practices.

Areas of key interest. The areas of interest are the priority areas where to execute actions or practices of quality and rigor while managing the IS-AR project. In this sense, and having present that the roadmaps are linked to project management processes of the PMBOK, the areas of interest are the 9 Areas of Knowledge of Project Management presented by the PMBOK itself (Integration, Scope, Cost, Time, Quality, Human Resources, Communication, Risk and Procurement, [PMI, 2000]), since they define the KPAs where you should act to get the criteria.

Practices. The practices are the basic actions to satisfy the criteria. These practices have been derived directly from the relationships between criteria and project management processes in each roadmap. Moreover, to make the practices coherent with the PMBOK, the practices for IS-AR project management have been named with similar names to those from the PMBOK. For example: to

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inspect, to revise or to register. The selection of the practices has taken into consideration the project management competence and the Action-Research proficiency levels. This selection lead to identify generic and specific practices, the first ones related with project management and the second ones related with specific IS-AR features.

When the roadmap is multilevel, or the practices or their tasks are more complex, they are executed in advanced levels. In this way, the practices have been leveraged along the maturity models. A selected roadmaps and their practices are shown in the Table 2, while the results of this process is shown in Table 3, which illustrates all the practices by level within each roadmap. The first and second columns in Table 2 are taken from [McKay and Marshall, 2001], while the third one indicates the practices by level in the roadmap. The last columns show the detail of practices by level in a roadmap. Table 3 depicts the total number of practices by category of quality and rigour criteria.

Table 2

Quality and rigor category	*Quality and rigor criteria/Roadmap*	*IS-AR maturity level*	# IS-AR project management specific practices		
			2	*3*	*4*
Credibility of the Research	Does it appear that there is a match between the constructions of Ps and those reported by R?	*3-4*	*0*	*3,5*	*0,5*
	Is there evidence of verification by P?	*3-4*	*0*	*6,5*	*1,5*
Confirmability of the Research	Is there evidence of an orderly process of data collection and analysis?	*3*	*0*	*6*	*0*
	Are findings and conclusions grounded in the data?	*2-3-4*	*2*	*2,5*	*1,5*
Practical Significance	Would Ps agree that some improvement in the problem situation had occurred as a result of the intervention?	*3*	*0*	*5*	*0*
	Does the research help alleviate problems that are evident in the IS discipline?	*3-4*	*0*	*4,5*	*1,5*
Presentation of research	Is the action research presented in such a way that there is evidence of logical rigour throughout the study?	*2-3*	*4*	*2*	*0*
	Are the links evident between a problem in the IS field, the literature review, theoretical framework, research method and design, and results / outcomes?	*2*	*2*	*0*	*0*

Table 3: Total of IS-AR project management practices

Quality and rigor category	*IS-AR maturity level*	# IS-AR project management specific practices by level		
		2	*3*	*4*
Research Method	*2*	*20*	*0*	*0*
Transparency of Process	*2-3-4*	*30*	*25*	*2*
Credibility of the Research	*3-4*	*12*	*16*	*7*
Transferability of the Research	*2-3-4*	*7*	*11*	*4*
Dependability of the Research	*3-4*	*0*	*13*	*2*
Confirmability of the Research	*3*	*3*	*12*	*5*
Impact on Participants	*2*	*9*	*0*	*0*
Research Skill	*2*	*12*	*0*	*0*
Conceptual significance	*2*	*12*	*6*	*5*
Practical Significance	*3*	*0*	*17*	*2*
Presentation of research	*2-3*	*13*	*8*	*0*
Total of generic practices		*118*	*108*	*27*
Total of specific practices		*17*	*29*	*6*
Total of practices by level		*135*	*137*	*33*
Total of practices				*305*

4.3. Implementation of the model

To get higher maturity levels we can take note of White' work ([White, 2000]). This means that a researcher can improve the use of IS-AR through the same cycles of Action-Research where, apart from solving a problem, he improves his own work. Thus, by taking into consideration the work of

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[McKay and Marshall, 2001], the Figure 3 shows maturity along a stream of research cycles and along a stream of practical cycles.
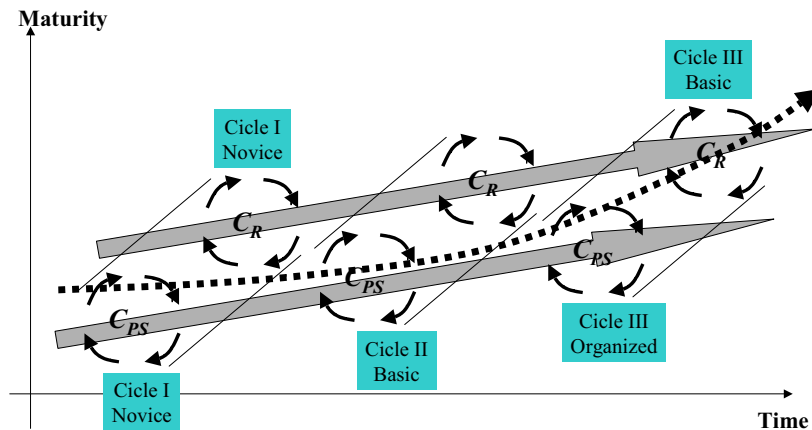

Figure 3

In this way, for example, by following the stages of a project (Initiation, Planning, Execution, Control and Closing), practices can be improved and interiorised gradually while the action-researcher advances in the phases of the cycle of Action-Research (Planning, Pl; Action, Ac; Observation, Ob; and, Reflection, Re). Thus, according to the quality and rigor criteria that are pursued, certain practices are executed in each phase/stage (Figures 4).
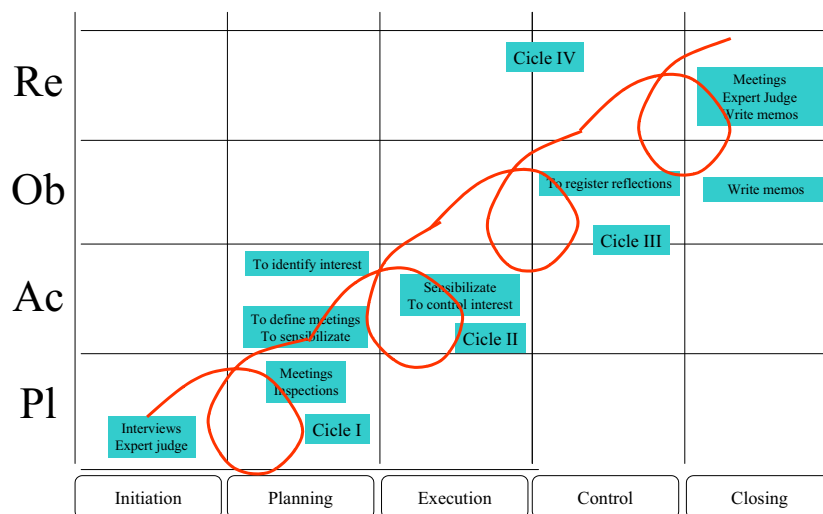

Figure 4

5.   COMMENTS AND FUTURE WORK

Our IS-AR project management maturity model has arisen from an extensive literature review and from our own IS-AR experiences on packaged software acquisition. The obtained model provides a mechanism of gradual learning that each researcher can adjust to his capabilities and potential, the studied problem and the research group. Future work is to apply the model in a systematic way and to produce a detailed guide for IS-AR project management, such as demanded by [Avison et al., 1999].

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