Action Research Use in Software Engineering: an Initial Survey

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Abstract

This paper presents a literature survey of action research (AR) studies published in nine major Software Engineering (SE) journals and three conference proceedings in the period 1993 to June 2009. A strict selection based on distinguishing SE from Information Systems research has identified 16 papers. Although they represent a very small fraction of the studies being conducted in SE, such papers concern with different SE contexts allowing to get information about the increasing tendency in the AR use in software engineering. However, as shown by the initial results, SE researchers should invest more on rigor when defining, applying and reporting AR studies in SE.

1. Introduction

The empirical method has become part of the Software Engineering (SE) research practice in recent years. Since the ultimate goal of SE research is to support practical software development, one essential aspect of its practice is the relevance of its contributions. Several researchers have already emphasized this issue [1,2,9]. Another important concern regarding the SE research is how to deal with the social facet of SE [3].

Action research methodology addresses both issues. It is regarded as "the most realistic research setting found, because the setting of the study is the same as the setting in which the results will be applied for a given organization, apart from the presence of the researchers" [1] and its application emphasizes "more on what practitioners do than what they say they do" [4]. These characteristics come from a background which is based on the assumption that theory and practice can be closely integrated by learning from the results of intervention that are planned after a thorough diagnosis of the problem context [5].

This paper presents a literature survey of AR studies published in nine major SE journals and three conference proceedings in the period 1993 to June 2009. We have identified 16 papers in the journals and conferences. Although it represents a very small fraction of the studies being conducted in SE, they concern with different SE contexts and thus are sufficient to exemplify to researchers the AR potentials.

This paper is organized as follows. First, we detail our research method. Then, we present the results and discuss the threats to validity. In the end, we analyze this paper contributions and further research.

2. Method

To conduct this survey, we have followed some of the criteria and steps of the approach employed in other literature reviews [6,7]. The journal and conferences chosen are the same as [6] which are considered relevant in SE research. The journals are ACM Transactions on Software Engineering Methodology (TOSEM), Empirical Software Engineering (EMSE), IEEE Computer, IEEE Software, IEEE Transactions on Software Engineering (TSE), Information and Software Technology (IST), Journal of Systems and Software (JSS), Software Maintenance and Evolution (SME), and Software: Practice and Experience (SP&E). The conferences are the International Conference on Software Engineering (ICSE), the IEEE International Symposium on Empirical Software Engineering (ISESE), and the IEEE International Symposium on Software Metrics (METRICS). The International Symposium on Empirical Software Engineering and Measurement (ESEM) was included in this survey as it merged METRICS and ISESE conferences used in [6].

The terms used for the search were gathered from [8]: action research, action learning, action science, reflective practice, critical systems theory, systems

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thinking and participative research. Using these terms we have found 162 papers from which 16 were selected. From the initial 162 papers 138 were eliminated by title and abstract, and the remaining 24 were entirely read. The main criteria applied when selecting the papers was evaluating if it really represented an AR study. To do this we drove our decision on the criteria for acceptable AR studies given by [7]: a real need for change, theory-based iterative problem solving, genuine collaboration with participants and honesty in theorizing research from reflection; and also used the AR principles defined by [5]: researcher-client agreement, cyclical process model, theory use, change through action and learn through reflection. But, driven by the presupposition that find an AR study in SE research that met all these criteria and principles would be difficult, we defined AR adherence levels to classify the studies. It aims at to be more open when selecting the papers. This and other information extracted from the papers are summarized in Tab. 1.

Table 1. Papers' extracted information

Information	Description		Based on
Problem	The research problem or AR diagnosis.		[7]
Action	Actions implemented.		[7]
Reflection	Reflections from the actions implemented and problem solution.		[7]
IEEE Taxonomy	Used to classify the research topics.		[10]
Adherence	Inspired – when the focus is on the researchers learning from a real problem resolution exploring SE research without strictly following the AR principles; Based – when the AR methodology is modified or combined with other empirical methods; Genuine – when the full essence of action research methodology is present.		–
Type	Action Research – focusing on change and reflection; Action Science – trying to solve conflicts between espoused and applied theories; Participatory Action Research – emphasizing participant collaboration; Action Learning – for programmed instruction and experiential learning.		[4]
Length	Length of the study.		[6]
Data Collection	Qualitative or Quantitative, including which techniques were used.		–
AR control structures	Initia-lization	Researcher – field experiment; Practitioner – classic action research genesis; Collaboration – evolves from existing interaction.	[13]
	Author-ity	Practitioner – consultative action warrant; Staged – migration of power to the client; Identity – practitioner and researcher are the same.	
	Forma-lization	Formal – written contract; Informal – broad, perhaps verbal, agreements; Evolved – informal or formal shift into oposite form.	
AR cycles	Number of AR cycles conduced.		[5]

We tried to be rigorous selecting only SE research papers, as some journals and conferences also contain Information Systems (IS) research. SE applies the computer science fundamentals to the development of software systems. IS is concerned with the business community needs in terms of computing, and especially information. Thus both SE and IS fields have certain elements in common – computing concepts, systems development, and information technology – but they also have clearly distinguishable goals [11].

Finally, it's important to underline that we have evaluated the papers strictly from its text. Eventually, some of them would have been evaluated differently if we had had access to a full research report or contacted the authors, particularly when authors give more emphasis on the findings at the research process expense [13]. This stresses the importance of having report guidelines, perhaps specifically for AR in SE.

3. Results

In this section we present three major results. First, the publications distribution along the years, journals and conferences is shown. Then we have two subsections to characterize the domains and contexts into which action research studies have been conducted and describe how they were executed.

Publications distribution is exhibited in Tab. 2 (only journals and conferences from where papers were selected are listed). Adherence levels defined earlier are in Tab. 2 abbreviated Inspired (I), Based (B) and Genuine (G). From the distribution we can see an increasing number of papers describing AR studies. Note that the last period (2005-2009) is one year shorter than the others.

Table 2. Selected papers distribution

Journals and Conf.	1993-1998			1999-2004			2005-2009		
	I	*B*	*G*	*I*	*B*	*G*	*I*	*B*	*G*
ESE				1			1		
ICSE						2			1
IEEE SW				1			1		
IST					1	1			3
SP&E	1					1		1	
TSE								1	
Totals	1			2	1	4	2	2	4
	1			7			8		

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The number of studies that are inspired in AR is relatively high, about 30%. This means that there is a need to improve rigor in AR studies if we want that AR investigations form a solid ground for further research and industrial applications in SE. This situation is even worse if we consider the studies that mentioned AR but were eliminated because couldn't even be classified in the lowest (i.e., inspired) adherence level.

3.1 Research Topics and Contexts

It is interesting to observe that AR is being applied to wide spectrum of SE research domains (Tab. 3) ranging from the more social side (e.g., Management) to the more technical end (e.g., Software Construction). The topic which had the largest number of studies was Software Engineering Process, and more specifically Process Implementation and Change. This is also the topic where most of the inspired adherence level articles were concentrated, mainly because their authors interleaved the software improvement process with the AR process leaving implicit when they were assuming the researcher role or the consulting role.

Table 3. Research topics

IEEE Taxonomy	# Papers
Distribution, Maintenance, and Enhancement	**2**
Documentation	1
Maintenance management	1
Management	**2**
Project control & modelling	1
Time Estimation	1
Requirements/Specifications	**2**
Elicitation methods	1
Process	1
Programming Environments/Construction Tools	**1**
Environments for multiple-processor systems	1
Software Architectures	**2**
Domain-specific architectures	1
Patterns	1
Software Construction	**2**
Data design and management	1
Programming paradigms	1
Software Engineering Process	**4**
Process implementation and change	3
Software Process Models	1
Miscellaneous	**1**
Software libraries	1

With respect to the problem/action/reflection extracted information we could classify it in three major formats: (1) evaluation of technology introduction through lessons learned (presenting similarities with case studies), (2) technology conception and/or tailoring with intense collaboration and changing through intervention focus (the AR most genuine format where the problem solution is initially unknown), and (3) SE activities facilitation and observation (having a consulting component).

In general, the more technical initiatives were close related to the formats (1) and (2). For example, one of the papers reports a maintenance methodology that was created into the context of an organization, while in other case the formalization of software architecture design rules in the context of model-driven development was introduced. In the other hand, the more social research efforts were related to the format (3) as it was the case of the software process improvement papers.

3.2 Second and following pages

The information extraction about the execution details was problematic. Many papers did not describe the data collection techniques, study length and number of AR cycles. Moreover, almost all papers have not explicitly defined the AR type and control structures. The AR control structures are an important component of an AR study execution because it makes explicit the process followed and why decisions were taken. The definition of the AR type, in turn, makes clear why some AR characteristics were emphasized. Although this information was not explicit, we could in some cases implicitly deduce them from the overall research actions and context description. Fig. 1 shows the number of papers by AR type and AR control structures. Examining the Fig. 1 we can see that most of the studies reported in the papers are of the type Action Research, and are started by practitioners which have authority over the research execution (identity authority) that is carried out without any formalization. This seems to be an interesting find because it possibly means that researchers are conducting studies considering a small number of organizational constraints. Nevertheless, it is worth reiterate the large number of papers that did not mention its control structures.

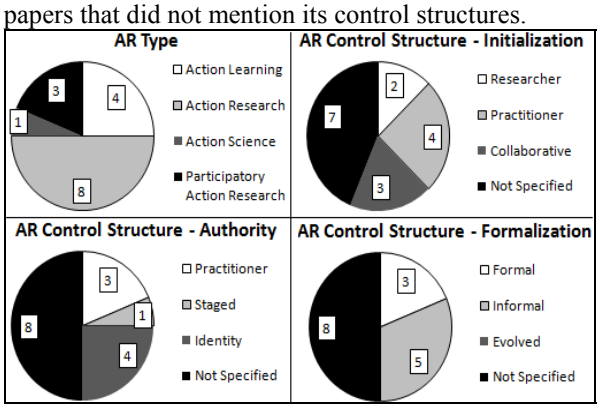

Figure 1. Selected papers classification by the AR types and control structures.

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All papers intensively made use of qualitative data, confirming this intrinsic characteristic of AR in SE. Three used quantitative data, indicating that quantitative research is also a possibility. Observation was by far the most mentioned data collection technique followed closely by interviews. For quantitative data, metrics were used in all papers.

At last, the studies length ranged from 2 months to 5 years (the mean was 21 months and 16 for the standard deviation). This result shows that AR use is very flexible regarding the study duration and is most influenced by the research topic, software technology and activities involved. Four studies have not specified its length. For the number of AR cycles, only two papers explicitly mentioned this and both have 1 cycle. But, from the linear description of the other papers we believe the same behavior can be expected for most of the other cases.

3.3 Threads to Result Validity

The main problem with this initial survey is the subjectivity of the classification. To help to avoid a biased selection process, carried out by one of the authors and reviewed by the other, we defined research objectives and selection criteria in advance, organized the selection of papers as a multistage process, and documented the reasons for inclusion/exclusion as suggested in [14]. Other important threat is the limited number of journals and conferences chosen for this survey, but we believe that they are as good as the same set used in other survey [6].

4. Conclusion

Literature surveys are a good way to have an overview of the state of the art of a research topic. Given the AR characteristics and the relevance and social challenges that SE researchers have to deal with, AR seems to be a useful research methodology. In fact, domains more similar to SE, in terms of research practice and challenges, as education and nursing [12], have a long history in successfully applying the AR methodology [4]. So we can foresee a promising future for AR in SE. The results from this initial survey indicate that this future can be not far. We had found out that there is an increasing tendency in the AR use in SE addressing different research topics. Our initial findings also indicate that the AR studies rigor and control should improve in SE. However, if these issues are already being addressed in the field but not reported, researchers should be more accurate about the research context and execution in publications. As stated by [15], the aim in AR should be to enact a process based on a declared-in-advance methodology in such a way that the process is *recoverable* by anyone interested in subjecting the research to critical scrutiny.

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