A classification of RE papers: Are we researching or designing RE techniques?

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1. Introduction

Discussion of a paper in RE program committees is often complicated by lack of agreement about evaluation criteria to be applied to the paper. For some years now, successive program chairs have attempted to increase clarity by including a paper classification in their CFP, and making the evaluation criteria per paper class explicit. This short note presents a paper classification based on this experience. It can be used as guide by program chairs. It can also be used by authors as well as reviewers to understand what kind of paper they are writing or reviewing, and what criteria should be applied in evaluating the paper.

2 Rationale of the classification

Starting point of this classification is the observation that RE researchers investigate RE, they also propose new solutions to RE problems. This means that they are engaged in engineering: Their aim is to improve RE. The logical structure of engineering action is the engineering cycle, which has the following logical structure:

(a) Problem analysis: Investigation of existing situation.
(b) Solution generation: Creative act in which one or more solutions are specified
(c) Solution validation: Investigation of proposed solution properties, and evaluation w.r.t. requirements identified in problem analysis
(d) Solution selection
(e) Solution implementation: Realizing selected solution.
(f) Implementation evaluation: Analysis of new situation and evaluation against requirements. Start of new engineering cycle.

The engineering cycle has been identified by different researchers in such diverse fields as product development and systems engineering [1, 2, 5, 7, 8, 10, 12]. This is because the engineering cycle is basically the structure of the rational decision process [9]. Note that the engineering cycle is the logical structure of a decision process. In real time, many of these tasks may be performed in parallel.

The engineering cycle contains a number of research activities, namely problem analysis (which problems exist in RE practice?), solution validation (what are the properties of a proposed solution?), and implementation evaluation (what are the experiences with this implemented solution?). These are research questions because they ask for knowledge. They ask what the properties of the problem are, what the properties of an unimplemented solution are, and what the properties of an implemented solution are, respectively. This contrasts with the other three tasks in the engineering cycle, solution generation, solution selection and solution implementation. These are all activities that result in a different state of the world. To answer a research question, the researcher must perform mathematical or empirical research. He or she must prove (mathematical) properties or investigate empirical phenomena. There are many kinds of mathematical and empirical research, each of which is evaluated by its own criteria. We will not give a classification of all kinds of mathematical and empirical research here, and below we will only give very general evaluation criteria, which are applicable to any kind of research. However, it is useful to distinguish two kinds of research questions in the engineering cycle, namely...
• evaluation of an existing situation (problem analysis and implementation evaluation) and

• validation of a proposed solution.

The difference between these two determines where one looks for the relevant phenomena: In real life (industrial RE practice) or in artificial situations (e.g. in a lab where experimental RE techniques are used). Our classification therefore includes these two classes.

In addition, the engineering cycle contains a design activity, namely solution generation. Natural science researchers would not consider this to be research, because they create designs (of experiments) in the service of acquiring knowledge. Publishing an unvalidated design of an experiment is not considered a research contribution in natural science. A research project proposal in natural science may very well include a description of an experiment yet to be implemented; but a research paper should describe the outcome of an implemented experiment. Engineering researchers, by contrast, are interested in unvalidated designs too, because engineers create designs that may be useful for anyone, for purposes never imagined by the engineer. One possible paper at an RE conference is therefore Proposal of a solution. A solution proposal may be supported by an illustration but need not be supported by methodologically sound validation research.

3 The classification

This leads to three distinct categories of papers.

1. Evaluation of existing situations. As explained above this comes in two variants, namely a study of a real problem to be solved and an evaluation of an implemented solution) In either case, the researcher studies causal or logical properties of techniques or processes in the real world. Causal properties are studied empirically, such as by case study, field study, field experiment, survey, etc. Logical properties are studied by conceptual means, such as by mathematics or logic. Evaluation criteria are:

• Is the problem clearly stated?
• Are the causal or logical properties of the problem clearly stated?
• Is the research method sound?
• Is the knowledge claim validated? In other words, is the conclusion supported by the paper?
• Is this a significant increase of knowledge of these situations? In other words, are the lessons learned interesting?

2. Proposal of solution. A solution technique for a situation recognized to be problematic is proposed. The technique is novel, or it is a significant improvement of an existing technique. A proof-of-concept is offered by means of a small example, a sound argument, or by students of the author. Evaluation criteria are:

• Is the problem to be solved by the technique clearly explained?
• Is the technique novel?
• Or is the application of this techniques to this kind of problem novel?
• Is it clearly stated so that the author or others can validate it in later research?
• Is the technique sound?
• Is the broader relevance of this novel technique argued?
• Is there sufficient discussion of related work? In other words, are competing techniques discussed and compared with this one?

3. Validation of proposed solution. Investigation of a designed solution, after specification but before implementation. The solution may have been proposed elsewhere, by the author or by someone else. The investigation uses a thorough, methodologically sound research setup. Possible research methods are experiments, simulation, prototyping, mathematical analysis, mathematical proof of properties, etc. Evaluation criteria are similar as for evaluation of existing situations.

• Is the technique to be validated clearly described?
• Are the causal or logical properties of the technique clearly stated?
• Is the research method sound?
• Is the knowledge claim validated? I.e. is the conclusion supported by the paper?
• Is it clear under which circumstances the technique has the stated properties?
• Is this a significant increase in knowledge about this technique?
• Is their sufficient discussion of related work?
Any of these papers can be written by researchers in academia or in industry. Note that the evaluation of existing situations includes most of what is currently called “state of the practice papers” or “industry reports”. We emphasize that this class of papers studies existing situations. These situations must exist independently of the researcher, i.e. they must exist in industry or government organizations.

The difference between validation in classes 2 and 3 is that in 2, a proof-of-concept can be offered that leaves open whether the technique can really be implemented in practice, and can function independently of the inventor, whereas in 3, a sound research method must be used to acquire knowledge about the proposed solution. In a paper of class 2 the proposed solution technique must be novel. It is sufficient if the author illustrates the technique using a small example, or reports that students have used the technique with success in the classroom. A paper of class 3 must report about rigorous validation research, such as an experiment involving others than the author or his or her students, or about simulations or prototypes that are exercised in realistic situations, or present mathematical proofs of knowledge claims. But unlike class 2 papers, the technique reported about does not have to be novel. The knowledge claim made by the paper, though, must be novel.

4 Other interesting paper classes

In addition to these research papers there are a few other categories of papers that do not use a research method nor propose a novel design, but are interesting for some other reason. This includes the following three categories.

4. Philosophical papers sketching a new way of looking at things, a new conceptual framework etc. Evaluation criteria:
   - Is it original?
   - Sound?
   - Insightful?

5. Opinion papers, with motivations and/or examples. Usually contains the author’s opinion about how we should do something. E.g. the REJ viewpoints. Evaluation criteria:
   - Is it original?
   - Sound?
   - Surprising?
   - Likely to provoke discussion?

6. Personal experience papers with lessons learned. The emphasis is on What and not on Why. The experience may concern one project or more, but it is the author’s personal experience. Papers in this category will often come from industry practitioners or from researchers who have used their tools in practice, without bothering to follow a particular research method. The evidence is anecdotal. Evaluation criteria:
   - Is it original?
   - Sound?
   - Revealing?
   - Is it relevant for practitioners?

5 Recommendation

We propose to call papers of classes 1, 2 and 3 technical research papers. Note that this includes most papers currently called “industrial papers”, because papers of class 1 are about real-world situations. Papers in class 1 and 3 report about new knowledge and should follow a sound scientific research method. They will be evaluated by checking that they followed a scientific method and whether the knowledge claim made in the paper is new. Papers in class 2 are about new designs and need not follow a scientific methods; rather, the contribution will be evaluated on technical soundness and novelty of the solution technique.

The remaining three paper classes do not present the result of scientific research or technically sound design, but are relevant for some other reason. It is to be recommended to define separate tracks for these, called philosophical papers, opinion papers and personal experience papers.

6 Discussion

Compared to Zave’s earlier classification of RE research efforts [13], our goal concerns methodology and not a delineation of topics that belong to requirements engineering. We are concerned with using a right research method (by authors) and proper evaluation criteria (by reviewers) and not with the RE topics that can be researched.

The role of scientific research methods has been debated by a number of researchers. Brooks [4] suggests that engineers is aimed at producing useful things and therefore do not have to follow scientific methods. At the other extreme is Auyang [3] who observes no difference between engineering research and other kinds of research, and gives many historical examples to substantiate this observation. She does recognize that engineers usually have a larger obligation than natural scientists to motivate their research by the expected utility of their results. This can be explained by our claim that engineers always do research in the context of the engineering cycle, the aim of which is to improve some technique.
Recently, researcher in software engineering have expressed concern about the lack of validation of results. Glass et al. [6] show that papers in Information Systems tend to be empirical (but propose no new solutions) whereas Tichy et al. [11] and Zelkowitz and Wallace [14] show that roughly, in about 30 to 50% of the software engineering papers that require validation, validation was found to be absent. This means that information systems papers tend to describe existing situations but propose no solutions, whereas software engineering papers tend to describe solutions but fail to validate them. Our proposal strikes a balance between these two extremes.

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References


