

Representation and structure in the re-use of design rationale by novice analysts

(Extended Abstract)

Georgios P. Iliadis
LUTCHI Research Centre
Department of Computer Studies
Loughborough University
Loughborough, UK

1. INTRODUCTION

1.1 *Background to study*

A central theme in this research is the use of design rationale to manage the breakdowns that take place as part of software design activities.

Breakdowns have variably been described as symptoms or causes of difficulties in the design process [4], instances that lead to the reframing of problems [3], or in a more general sense, as occurrences of object/idea emergence [7], to mention a few. They seem to play a large role in design behaviour. They directly affect the decision making process and subsequently the course of action, and vice versa. A common piece of ground in all types of breakdowns is the lack of readily available knowledge of strategies that correspond to the particular problem class.

Design rationale (DR) refers to the argumentation that underlies the decisions made during the design of an artefact and has been used in several studies to provide readily available design knowledge. Fischer [3] uses 'seeded' modules of argumentation out of previous designs to facilitate breakdowns and subsequent knowledge discovery, and thereby guide designers. Karsenty [5] found DR to be a useful source of knowledge when designers try to re-use design documents in a real project.

1.2. *Goals*

The on-going study presented in this paper investigates the potential of DR to transfer (a) expertise and (b) process-related information to novice analysts/designers. By making available the train of arguments and thoughts of a previous (expert) designer(s), as well as any associated heuristics that were used, novice analysts should be able to contribute to the solution. In particular, we are putting together a task scenario of DR re-use and we are concerned with:

- (a) which type of representation is most suitable to a typical design problem and
 - (b) what is the role of the structure of the argumentation material in such a context.
- Can we gather any information out of it about the structure of reasoning that has taken place?

2. EXPERIMENT

2.1 Hypotheses

2.1.1 DR representation

DR comes in different forms. Among others, Conklin [2] has proposed a type of graphical argumentation. Buckingham Shum [1] has put forward a tabular form, whereas Fischer [3] predominantly uses a narrative one. It would be interesting to see the effect of these different notational types to the thinking of a novice analyst trying to make sense of a set of DR fragments.

We use the QOC formalism [6] as a platform on which to test different representational aspects of DR. QOC is a DR representation whose basic elements are Questions, Options and Criteria. Questions stand for issues that come up during the design task, Options stand for alternative answers to the Question at hand and Criteria are meant to be objectives under which each option is evaluated for fitness. Criteria can be assessed either positively or negatively, leading to a decision.

Our intuition is that a tabular DR form would be more suitable to making sense of syntactic aspects of DR, a narrative form would be more useful in eliciting semantics out of a DR fragment, whereas a graphical one would probably be more suitable when a combination of multiple (related) fragments is required. No prediction is made on the overall performance.

2.1.2 DR structure

On a relevant note, MacLean et al. [6] suggest the roles of the different DR elements. He mentions that : ‘the role of Questions is generative and structural, not evaluative. We must next consider how to evaluate the Options and to rationalise the decisions.’, “The QOC representation emphasises the systematic development of a space of design Options, structured by Questions.” and also that “The QOC representation brings the objectives for the design, in the form of Criteria, into explicit focus.”.

This leaves us with a fairly large space of options on how a DR document based on QOC would be read in order to provide a thorough understanding of the material to the level that one can make judgements and suggest alternative proposals towards the design solution. We are interested in seeing how the structure of the material together with the order in which it is presented can make a difference in comprehension and subsequent problem-solving performance.

We use two different types of the narrative QOC form, in order to investigate that issue. One is leading the reader from options to criteria and the other one is leading from criteria towards options. We hypothesise that in a reviewing/evaluating mode, the latter is more suitable and would thus increase subject performance.

2.2 Method

2.2.1 Subjects

Subjects were first-year undergraduate students at Loughborough University doing either Information & Computing, or Computing & Management. Both 'computing' parts of these courses offer the same curriculum in the first semester, which includes a course on Systems Analysis and Design and a course on Programming. A fair prize in cash is to be drawn at the end of the experiment and 18 subjects have volunteered. The experiment is also presented to them as an educationally beneficial experience.

2.2.1 Design

There are 2 independent variables: **representation** (narrative Vs tabular Vs graphical) and **structure** (options-based Vs criteria-based) which was implemented under the narrative condition. Expanded over 3 types of task questions: syntax, semantics and context, gives us a total of 15 conditions. There are 2 dependent variables: proportion of **correct answers** and **response time**.

There are also four qualitative measurements, namely intuitiveness/ease to comprehend, suitability, effectiveness, and overall preference.

A repeated-measures design is employed, with subjects being exposed to all conditions in a single session. Subjects were assigned to conditions randomly.

2.2.3 Materials

The stimulus material was drawn out of the FATM problem included originally in [6]. A set of 8 issues were given, of which 5 were related - two were siblings implied by a third one, and another one was a child of a fifth one.

The task material was a set of questions referring to different parts and aspects of the DR material and arranged in 3 tasks. Each task included 7 questions, thus giving a total of 21 questions per session.

A re-use in this setting was seen as a comprehension of the syntax, semantics, and context of DR fragments. Thus each task included 3 types of questions. *Syntactic* questions (3) would give a (or part of a) DR element and request another. *Semantic* questions (2) would either give or imply an (or part of an) element and request either another element or an inference on the part of the subject. *Contextual* questions (2) would give an element and request another element from an associated issue.

2.2.4 Procedure

In a training session, participants were given a tutorial on all forms of DR using QOC. A short exercise followed which introduced subjects to the domain of the main task. In the subsequent practical session preceded by the randomisation procedure and a short rehearsal, participants were handed the tasks one at a time. In this session subjects were videotaped and the camera advanced timer was used to obtain response time measurements. On completion of the tasks, subjects filled-in a preference questionnaire and a short debriefing session took place at the end.

2.3 Results

Training session

In the training session some people found it hard to come up with a set of 2 criteria for justifying having either a single or multiple slots on an ATM (cash machine). It was made clearer to them when prompted to see criteria as desirable system attributes, or design objectives. Less subjects found it hard to make up a set of input options for cash amount selection. That leads us to think that the semantics of QOC elements are intricate as a first-time subject and should be elaborated extensively in DR teaching.

Practical session

In a nutshell, preliminary results show that a narrative format is overall harder to comprehend, with the tabular and graphical formats giving a close battle among themselves. As far as the structure of argumentation material is concerned, the criteria-based approach produces a significantly higher proportion of correct answers.

Representation

The following table indicates the overall task performance under each primary condition.

	Narrative	Tabular	Graphical
Response time (avg. - secs)	44.9	35.7	32.9
Correct answers (avg. %)	55	63	67

In terms of response time, there was no marginal win over task types. On syntax, graphical was first whereas narrative was largely third. On semantics, tabular was first and again, narrative response times were much higher. On context, narrative was first and tabular largely third.

In terms of correct answers, winning scores are also fairly close with an exception of the semantic category where narrative seems to be producing many more correct answers. On the contrary, it produces a fair less of correct responses in the context type.

Argumentative structure

The following table indicates the overall task performance under each primary condition.

	Options-based	Criteria-based
Response time (avg. - secs)	44.9	44.87
Correct answers (avg. %)	48	73

In terms of response time, on the syntactic tasks the options-based argumentative structure outperformed the criteria-based structure whereas the reverse was true on the semantics and context tasks.

In terms of correct answers, the criteria based approach outperformed the options-based approach on syntactic and semantic tasks, whereas no large difference was found on the context task, with the options-based approach doing slightly better.

Questionnaire session

The tabular form was voted as the most suitable one for the task, and the graphical was voted as the most effective one. No particular differences on the intuitiveness category.

In terms of overall preference, the tabular DR form was by far the most preferred one, with the narrative and graphical receiving equal scores.

3. CONCLUSIONS AND FURTHER WORK

This experiment tested a set of:

(a) different representations (narrative, tabular and graphical),
(b) argumentation structures (options-based, criteria-based) for design rationale re-use. The task included the comprehension of syntax, semantics and context of the design of a cash machine by novice analysts. Although at this preliminary stage it is difficult to draw any definite conclusions, it seems that the tabular form is the easiest for novice analysts to grasp as it is fairly compact. The graphical one is convenient to work on as it is very expressive, whereas the narrative form was a bit awkward to browse, but on focus it did prove quite useful. The criteria-based form was certainly a very productive alternative to the options-based approach. The tabular form being the subjects' favourite is an interesting sign, considering that unlike the other two forms, no software tools exist that support that form.

In the future, more emphasis is to be placed on the second part of a re-use situation i.e. the problem-solving part, as that is more directly associated to breakdown situations. In another experiment to start shortly, a group of experienced designers will be involved in a fairly complex task. The main difference will be the expansion of the context section to the rest of the design documents, primarily to the sketch of the design product itself. Also, the merits of two-abstraction-level formalisms with respect to re-use tasks will be investigated.

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