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GUIDING THE PROCESS OF REQUIREMENTS ELICITATION TROUGH SCENARIO ANALYSIS : RESULTS OF AN EMPIRICAL STUDY

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Guiding the Process of Requirements Elicitation through Scenario Analysis : Results of an Empirical Study[1]

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Abstract

The CREWS 21.903 long term research ESPRIT project has proposed several strategies to support requirements elicitation through textual scenarios analysis. In the CREWS-L'Ecritoire approach, guidelines are proposed to systematise these strategies. To evaluate the effectiveness of the CREWS-L'Ecritoire requirements elicitation guidelines, an empirical study was undertaken. This paper presents an overview of the experiment results. These indicate that : (i.) subjects apply the CREWS-L'Ecritoire guiding rules with different rates of efficiency, (ii.) in average, all the guiding rules improve the subjects' ability to elicit correct requirements, and (iii.) each of the guiding rule has a different rate of efficiency.

1 Introduction

The CREWS-*L'Ecritoire* approach [5] proposes to exploit a bi-directional coupling between goals and scenarios to support the requirements elicitation process. On the one hand, when a goal is discovered, the approach proposes to author a scenario to illustrate it ; this applies the coupling in the forward direction. On the other hand, the approach proposes to analyse every scenario to yield new goals ; this applies the coupling in the backward direction. Starting from a high level problem statement, the CREWS-*L'Ecritoire* approach guides the top-down discovery of a complete hierarchy of goals illustrated by scenarios.

The exact sequence of steps of the CREWS-*L'Ecritoire* requirements elicitation process is :

1. Initial Goal Identification
repeat2. Goal Analysis
3. Scenario Authoring
4. Goal Discovery
until all goals have been elicited

It can be seen that goal elicitation and scenario authoring are complementary steps and goals/requirements are incrementally discovered by repeating the goal-analysis, scenario-authoring, goal-discovery cycle. In the resulting collection of goals and scenarios, each scenario illustrates a specific way of achieving a goal. These goal-scenario pairs are organised in AND/OR-like trees, and classified according to their level of abstraction. A refinement relationship is also proposed to relate goals that belong to different levels of abstraction.

To systematise the guidance of this process a set of guidelines has been proposed. The guidelines consist (i.) in *automated rules* to guide goal analysis and discovery, and (ii.) in *writing guidelines* and *linguistic analysis and verification rules* to guide scenario authoring. Moreover, goal discovery is guided according to three strategies : the *alternative strategy*, the *composition strategy*, and the *refinement strategy*. Several guiding rules are proposed to automate the achievement of each goal discovery strategy. Guiding rules supporting the alternative strategy help discovering goals identifying alternative ways of achieving a given objective. Guiding rules supporting the composition strategy discover goals identifying collections of system functions that are necessary to define a completely functioning system. Guiding rules supporting the refinement strategy help discovering goals at a lower level of abstraction than a given one.

So far, the CREWS-*L'Ecritoire* approach was detailed in [4] [5] [1] [2], its process was modelled [7] [6], it was implemented in a software prototype [8], and the scenario authoring guidelines were evaluated [3]. However, there is still little evidence concerning the effectiveness of each individual CREWS-*L'Ecritoire* guiding rule for goal analysis and goal discovery. An empirical evaluation was thus undertaken with post graduate students of the University of Paris 1 – Sorbonne. The 41 subjects (26 male and 15 female) had experience in Information Systems; all of them were aware of object oriented analysis and design methods, and had received a half day seminar on the use of scenarios in requirements engineering.

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To evaluate individually each of the CREWS-*L'Ecritoire* guiding rules for goal analysis and discovery, the following set of hypotheses was formulated.

H1 : the CREWS-*L'Ecritoire* goal statement rule helps formulating *more precise* goals

H2 : the CREWS-*L'Ecritoire* guiding rule supporting the discovery of design alternatives, when used at the contextual level, helps *better envisioning* the future system

H3 : the CREWS-*L'Ecritoire* guiding rules supporting the alternative strategy help finding *more variations* than an ad hoc process

H4 : the CREWS-*L'Ecritoire* guiding rules supporting the alternative strategy help better finding *variations which are at the same level of abstraction*

H5 : the CREWS-*L'Ecritoire* guiding rules supporting the alternative strategy help *better separating concerns* of alternative behaviour descriptions

H6 : the CREWS-*L'Ecritoire* guiding rules supporting the composition strategy help finding *more system functions* than an ad hoc process

H7 : the CREWS-*L'Ecritoire* guiding rules supporting the composition strategy help better finding *system functions* which are *at the same level of abstraction*

H8 : the CREWS-*L'Ecritoire* guiding rules supporting the composition strategy help better *separating system functions*

H9 : the three predefined levels of abstraction help better *preserving the consistency of action descriptions* within a scenario

The evaluation of hypotheses H1 to H9 was driven by a quantitative measurement of the difference between the subjects' results at tasks in which they had to perform goal analysis and discovery without any guidance, then with the CREWS-*L'Ecritoire* guiding rules.

This paper outlines the results of the evaluation of each individual hypothesis, and concludes with possible impacts on the design of the CREWS-*L'Ecritoire* approach and tool environment.

2 Evaluation of hypothesis H1

To guide the correct statement of goals, CREWS-*L'Ecritoire* proposes a goal template providing with structure and semantic content of goal components. Hypothesis H1 was validated in two respects : (i.) the goal template does help differentiating goals from other kinds of requirements, and (ii.) it helps reformulating goals more correctly. These two aspects are dealt with in turn in the following.

To evaluate hypothesis H1, the subjects were first asked to identify correct goals from a list of given statements. Without guidance, 65% of subjects were able to identify at least one correct goal. Using the goal template this proportion is increased to 90%. In average, the goal template improved the subjects' ability to identify correct goals by 25%.

Moreover, 82% of the subjects were able to correctly reformulate at least one more goal with guidance than without. Therefore, the subjects' results show that the goal template improve the ability to correctly reformulate goals that were incorrectly stated. In average, the subjects' performance for this task was increased owing to the goal template by 46%.

Figure 1 compares the proportion of subjects having correctly reformulated from 0 to more than 6 goals with and without guidance. The figure shows that owing to the goal template, 44% of subjects were able to correctly reformulate more goals than the best subject could do without guidance.

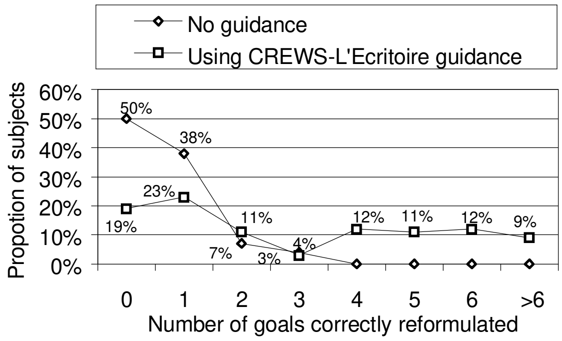

Figure 1 : subjects' performance in goal reformulation

3 Evaluation of hypothesis H2

To evaluate H2, the subjects were asked to find design alternatives with and without guidance. To systematise the discovery of design alternatives, CREWS-*L'Ecritoire* proposes a rule. The principle of this rule is to combine possible alternative values of goal parameters so as to generate new goals.

Figure 2 compares the number of correct design alternatives found by subjects without guidance and using CREWS-*L'Ecritoire* guiding rule. The figure shows that whereas the subjects were only able to find a little number of design alternatives on their own, the guiding rule helped them finding high numbers of correct design alternatives.

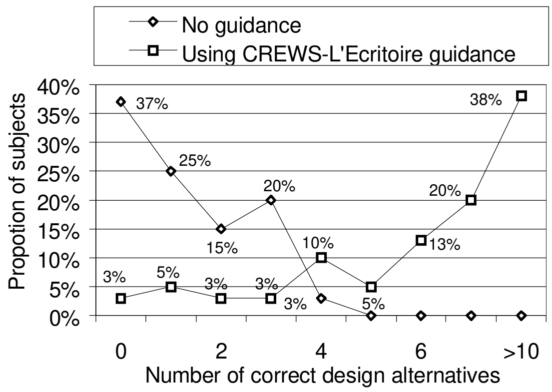

Figure 2 : subjects' performance in finding design alternatives

We observed that 76% of the design alternatives found without guidance were relevant. This average increased up to 96% when subjects used the CREWS-*L'Ecritoire* guiding rule. In absolute values the number of correct design alternatives discovered by the subjects was multiplied by 8 owing to the CREWS-*L'Ecritoire* support. Additionally, we could observe that CREWS-*L'Ecritoire* guidance was useful to most subjects. 95% of them did actually improve their performance.

The CREWS-*L'Ecritoire* guiding rule supporting the discovery of design alternatives helped most of the subjects to identify significantly more design alternatives which were in proportion more correct. Hypothesis H2 is thus, very strongly validated.

4 Evaluation of hypotheses H3 and H4

We could observe that subjects were already able to identify a large number of scenario alternatives on their own. However, the alternative goals discovered without guidance were in large proportion (42%) incorrect.

To guide the discovery of alternative goals, CREWS-*L'Ecritoire* proposes a rule which principle is to check for flows of actions which are not dealt with in the alternative scenarios of the analysed one.

When applying the CREWS-*L'Ecritoire* guiding rule, most of the incorrect alternatives discovered without guidance were either corrected or removed. Our initial observation is thus that : (i.) hypothesis H3 (CREWS-*L'Ecritoire* guiding rule supporting the alternative strategy improves the *number* of discovered alternative goals) is not strongly validated as such, but (ii.) the CREWS-*L'Ecritoire* guiding rule helps improving the quality of the collection of alternative goals proposed by subjects. It seems thus, that the guiding rule supporting the alternative strategy improves the quality of the result rather than the performance of the subjects.

Figure3 compares the distribution of subjects who have discovered given proportions of correct/incorrect alternative goals with and without guidance.

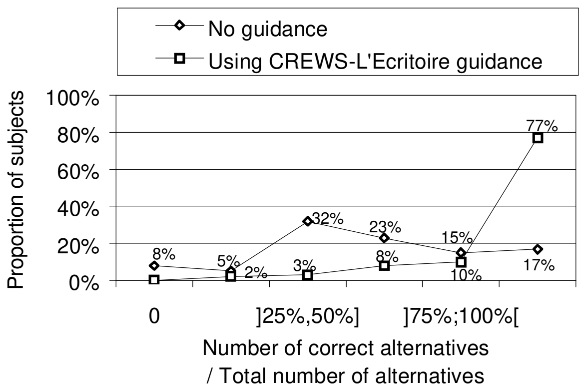

Figure 3: subjects ability to identify collections of alternative goals having given rates of quality

The figure shows that when they were helped by CREWS-*L'Ecritoire guidance*, the subjects were able to increase the proportion of correct alternatives by 35 % in average. The proportion of correct alternative goals discovered without guidance was of 58% and the proportion of correct alternative goals discovered with CREWS-*L'Ecritoire* guidance was of 93%. Let's notice that most of the 60% of incorrect alternative goals identified without guidance were due to an invalid level of abstraction. Using CREWS-*L'Ecritoire*, this error decreased down to 7%. Owing to CREWS-*L'Ecritoire*, 82% of subjects were able to eliminate all the variants initially identified at an incorrect level of abstraction.

5 Evaluation of hypothesis H5

To evaluate hypothesis H5, subjects were asked to identify alternative flows of actions described in a single scenario. We observed that a small proportion of subjects (11%) were able to perform this task correctly on their own.

Figure4 compares the proportion of subjects having correctly identified alternative flows of actions from the given scenario with and without CREWS-*L'Ecritoire* guidance. The figure shows that 39% of subjects who could not perform the task correctly without guidance were able to answer correctly once provided with CREWS-*L'Ecritoire* advice. Hypothesis H5 is thus confirmed.

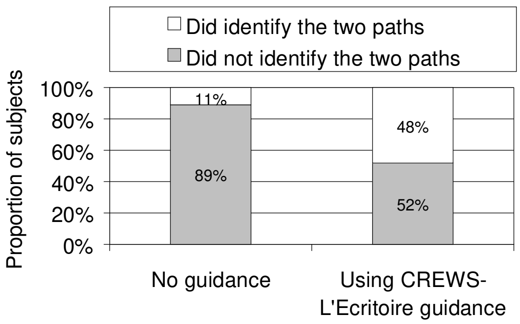

Figure 4: subjects performance in the identification of several flows of actions from a given scenario

6 Evaluation of hypotheses H6 and H7

To evaluate hypotheses H6 and H7, subjects were provided with a scenario illustrating the use of a system function, and asked with and without guidance to identify complementary functions of the system. We initially observed that CREWS-*L'Ecritoire* guidance helped : (i.) finding more system functions, and (ii.) finding more homogenous system functions with respect to the level of abstraction.

Most of the system functions discovered without guidance were incorrect. Incorrect system functions were due to an inadequate level of abstraction, and to confusions between complementary and alternative system functions.

Once provided with CREWS-*L'Ecritoire* guiding rules, more than 80% of subjects were able to correct the collection of system functions they were initially proposing. Actually, 96% of subjects could provide at least one correct system function using the guiding rules, whereas without guidance, 92% of subjects did not provide a single correct system function. The subjects' performance in the discovery of complementary system function was thus improved by CREWS-*L'Ecritoire* guidance.

Moreover, the proportion of incorrect system functions discovered by the subjects reduced once the subjects were provided with CREWS-*L'Ecritoire* guiding rules. Hypothesis H6 is thus confirmed.

The main error that the CREWS-*L'Ecritoire* guiding rules supporting the discovery of complementary system function helped avoiding was the confusion between alternative and complementary system functions. Indeed, 35% of subjects did the at least once when they were not guided. Once guided 92 % of subjects did not make this error anymore.

This observation is detailed in Figure 5 which compares the distribution of subjects having identified predetermined numbers of complementary system functions stated with and without guidance at an incorrect level of abstraction. The figure shows that without guidance most of the subjects have stated complementary system functions at different levels of abstraction. On the contrary, using CREWS-*L'Ecritoire* guiding rules, only a small proportion of subjects have made this error. Hypothesis H7 is thus validated too.

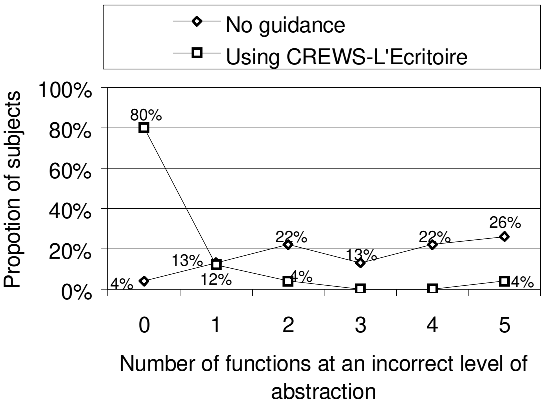

Figure 5 : distribution of subjects having identified collections of complementary system functions having given rates of quality

7 Evaluation of hypothesis H8

To evaluate hypothesis H8, the subjects were requested to identify several system functions hidden within a scenario they were provided with. Three system functions were expected.

A relatively small proportion of subjects (15%) was able to identify the expected system functions without guidance; we observed a significant improvement when subjects were provided with the adequate guidance. This is shown in Figure 6 which compares the subjects' ability to perform correctly the task with and without guidance. As Figure 6 shows, 39% of subjects who did not distinguish the three expected system functions without guidance were able to identify all of them once they were guided.

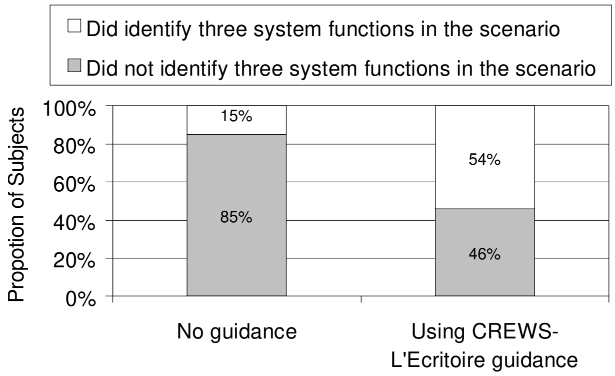

Figure 6 : subjects ability to identify several system functions in a scenario

8 Evaluation of hypothesis H9

To evaluate hypothesis H9, the subjects were asked to classify the actions described of a scenario they were provided with, with respect to their level of abstraction.

Without guidance, 80% of subjects were not able to detect that the proposed scenario was containing actions at different levels of abstractions. On the contrary, once they were asked to use the definitions of the three CREWS-*L'Ecritoire* levels of abstraction [5], all the subjects were able to tell that the scenario was inconsistent. Hypothesis H9 is thus validated. However, we also observed that the three pre-defined levels were not equally understood. The remaining of this section detail these differences in the understanding of the three levels of abstraction.

Behavioural level : the actions belonging to the behavioural level should describe exchange of services between a system, its users, and other external systems. Within the set of actions classified as belonging to the behavioural level 47% were correctly classified. Moreover, 72% of the subjects proposed an incorrect collection of actions at the behavioural level.

Functional level of abstraction : the actions belonging to the functional level should describe interactions between a system and its users. 84% of the actions classified at the functional level were indeed belonging to this level. Additionally, 56% of subjects proposed a correct set of actions of the functional level.

Physical level of abstraction : the actions of the physical level should describe the behaviour of the internal components of a system. The set of actions classified at the physical level was in average correct at 96%. Moreover, 88% of subjects did propose an entirely correct set of physical actions.

Hypothesis H9 is thus validated, but with different rates of efficiency for each of the three CREWS-*L'Ecritoire* levels of abstraction.

9 Conclusions

The evaluation results presented in this paper show that the guidance provided by the CREWS-*L'Ecritoire* approach to support goal analysis and discovery is effective. However, we also observed differences in the effectiveness of the different CREWS-*L'Ecritoire* guiding rules.

To evaluate individually the effectiveness of each guiding rule, a set of hypotheses was emitted on each of them. Some of these hypotheses, like H1 ("the CREWS-*L'Ecritoire* goal statement rule helps formulating *more precise* goals"), or H2 (which concerns the guidance of design alternative discovery) were very strongly validated. Others, like H3 and H4 (which concern the support of the discovery of alternative goals), or H5 and H6 (which concern the support of the discovery of complementary goals) had to be mitigated. Indeed, we observed that subjects were able to discover alternative and complementary goals on their own. However, a very large number of errors were made during the non-guided discovery; most of these errors were corrected owing to CREWS-*L'Ecritoire* guidance. The effectiveness of the CREWS-*L'Ecritoire* alternative and complementary goal discovery rules lies thus in the improvement of the product quality rather than in the number of discovered goals.

From the point of view of the CREWS-*L'Ecritoire* tool, the implication could that the guiding rules help as well for verifying and correcting the discovered collections of goals as for stimulating the discovery of new goals. Our first observations of the use of CREWS-L'Ecritoire guiding rules in an automated tool environment seem to confirm this hypothesis.

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References

[1] C. Ben Achour. Guiding Scenario Authoring. Proc. of the 8th European - Japanese Conf. on Information Modelling and Knowledge Bases. Vamala, Finland, May 1998.

[2] C. Ben Achour. Extraction des Besoins par Analyse de Scénarios Textuels. PhD thesis University of Paris 6, France, Jan. 1999.

[3] C. Ben Achour, C. Rolland, N. Maiden, C. Souveyet. Guiding use Case Authoring : Results of an Empirical Study. Proc. of 4th IEEE Int. Symp. on Requirements Engineering, Limerick, Ireland, Ju. 1999.

[4] C. Rolland, C. Ben Achour. Guiding the Construction of Textual Use Case Specifications. Data & Knowledge Engineering Journal Vol. 25 N° 1, Elsevier Science. Mar. 1997.

[5] C. Rolland, C. Souveyet, C. Ben Achour. Guiding Goal Modelling using Scenarios. IEEE Transactions on Software Engineering, Vol. 24, No. 12, Dec. 1998.

[6] C. Rolland, A. Benjamen. A Multi-Model View of Process Models. To appear in Requirement Engineering Journal, 1999.

[7] S. Si Saïd, C. Rolland. Formalising Guidance for the CREWS Goal-Scenario Approach to Requirements Engineering. Proc. of the 8th European - Japanese Conf. on Information Modelling and Knowledge Bases. Vamala, Finland, May 1998.

[8] M. Tawbi, C. Souveyet. Guiding Requirement Engineering with a Process Map. Proc. of 2nd Int. Workshop on the Many Facets of Process Engineering, Gammarth, Tunisia, May 1999.