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Creativity Techniques for Requirements Elicitation: Comparing Four-Step EPMcreate-Based Processes

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***Abstract*—[Context and motivation] The Elementary Pragmatic Model Creativity Technique, a.k.a EPMcreate, is a method for creative requirements discovery. It includes 16 steps corresponding to all the possible combinations of two classes of stakeholders' viewpoints. The feasibility and effectiveness of the full 16-step process have been confirmed by a number of experiments. The need to reduce the number of steps was observed in the very first experiments run in 2003. To address that problem, a few years later, a four-step creativity technique, POEPMcreate (Power-Only EPMcreate), was defined and tested. [Question/problem] More recently, the general problem of downsizing EPMcreate to define lighter weight processes based on sub-sets of the 16 steps has been theoretically investigated. The theoretical analysis demanded experimental confirmation. [Principal idea/Goal] This paper describes an experiment applying and comparing two four-step techniques, POEPMcreate and a new technique, ROSEPMcreate (Redundant, Odd Step EPMcreate), resembling traditional requirements elicitation with brainstorming. [Contribution] The results of the experiment, even if preliminary, seem to indicate that ROSEPMcreate is at least as feasible and effective as POEPMcreate. The results also give new insights and suggest issues to be considered in future experiments. The paper also offers Kano categories as a new way to evaluate the innovativeness of generated requirement ideas.**

Keywords-Elementary pragmatic model; creativity technique; viewpoint; creativity process; requirements elicitation

I. INTRODUCTION

Creativity techniques can be successfully applied to elicit requirements. The literature offers a variety of approaches and research about them. Among them, we can cite [1], [2], [3] and the papers of the CreaRE workshops, a REFSQ satellite whose home sites are <https://sites.google.com/site/creare2018> and <https://sites.google.com/site/creare2017> (and from there, to previous years' sites). Additional literature is cited in the discussion below. One of the parameters that can be used to classify these techniques is the number of phases or steps characterizing their creative elicitation processes.

This paper focuses on variations of the Elementary Pragmatic Model Creativity Technique, a.k.a. EPMcreate, which provides a 16-step process for creative requirements elicitation [4]. The theoretical basis of the technique builds on (1) the pragmatics of communication [5] and on (2) the assumption that creativity is crucial for problem definition and problem solving [6]. According to EPMcreate, requirements are ideas to fulfill needs of stakeholders having different viewpoints, and the viewpoints of a pair of different stakeholders can be combined in 16 different ways, suggesting a 16-step elicitation process.

A number of experiments have confirmed the feasibility and the effectiveness of EPMcreate [4], both as a group and as an individual requirement elicitation technique [4], [7]. The most recent experiments have investigated if it is possible to adopt a process based on a subset of steps of EPMCreate [8], [9], [10]. Given the high number of combinations of the 16 steps [9], it is necessary to choose the steps to be included in a proposed new technique, using sound selection criteria. For the first technique with a reduced number of steps, the adopted criterion was that of coverage, that is, using only the steps corresponding to the four not overlapping combinations of two stakeholders' viewpoints. Since these four steps are those named for the first four powers of two, the technique was named Power-Only EPMcreate (POEPMcreate) [8]. More recently, Mich, Sakhnini, and Berry investigated the problem of downsizing EPMcreate to define lighter weight techniques based on subsets of the 16 steps [9]. The paper considered a number of criteria for generating lighter creativity techniques, each based on a subset of the 16 steps of EPMcreate. It explored some possible 1-, 2-, 4-, and 8-step techniques. Its main conclusion is to call for experimental evaluation of the effectiveness of specific techniques. The present paper is one fulfillment of this call.

In this paper, POEPMcreate is compared with ROSEPMcreate (Redundant, Odd Step EPMcreate), another four-step variant of EPMcreate. ROSEPMcreate includes activities that − albeit in different ways − are usually included in the traditional requirements elicitation sessions. An experiment was designed and run with student analysts working in teams of two. The results add more information to that gathered in the previous experiments and suggest new issues to be addressed in future experiments.

In the rest of the paper, Section II illustrates the steps of EPMcreate, the bases for the four-step techniques compared in the experiment. Section III describes the experiment. The main results and their analysis are given in Section IV. Section V describes the threats to the validity of the results, and Section VI concludes the paper.

II. THE 16-STEP CREATIVITY TECHNIQUE

Each of the 16 steps of EPMcreate corresponds to a different combination of the viewpoints of two stakeholders. These combinations can then be denoted using a Boolean function of two binary variables [11]. The 16 Boolean functions are binary connectives, and the most known of them are the logical AND, OR, and XOR, which in terms of requirements correspond to the situations in which the analyst is trying to generate requirements that are needed by both the identified stakeholders (AND); by any of them (OR); and by one or the other but not by both of them, (XOR), i.e., by either of them. Also the always-false and always-true functions are included in the EPMcreate process as the first and the last steps, respectively. Table I illustrates the steps in terms of their logical combinations of viewpoints, VP1 and VP2, of the stakeholders, SH1 and SH2, respectively; their Venn diagrams; and their interpretations.

In general, EPMcreate can be considered a conceptual framework that supports the generation of requirements elicitation techniques with any number, from 1 through 16, of EPMcreate's steps. Given that testing all possible combinations of steps is impossible, the problem is to find sound principles with which to select for a technique steps that are more adequate, effective, or feasible.

III. THE EXPERIMENT

A. Two 4-step techniques

We wanted to empirically validate that ROSEPMcreate, a new four-step variant of EPMcreate, could be used to support requirements elicitation. To this end, we decided to conduct an experiment to compare ROSEPMcreate to POEPMcreate, whose effectiveness has already been empirically validated [8].

POEPMcreate was defined [8] to not include any redundancies, i.e., each of the four regions of the Venn diagram, the atoms of the Boolean algebra for two variables [11], is explored only once. It thus consists of Steps 1, 2, 4, and 8 in Table I.

ROSEPMcreate consists of Steps 3, 5, 7, and 15 in Table I. Each of Steps 3 and 5 focuses on the needs of one stakeholder, even as these needs might coincide with the needs of the other stakeholder. Next, Step 7 focuses on the needs of either or both stakeholders. Finally, Step 15 is a catch-all step in which the analyst is invited to think of any possible requirement idea. The overlap of the foci of Steps 3 and 5 is in distinction to that of each of Steps 2 and 4, in POEPMcreate, that focuses on the needs of one stakeholder to the exclusion of the needs of the other. Observe that the focus of Step 7 overlaps the focus of each of Steps 3 and 5, and that the focus of Step 15 overlaps the focus of each of Steps 3, 5, and 7. In addition, Step 15 corresponds to the question, "Anything else?" and to one of the principles of brainstorming [12], "Do not worry about feasibility or any other issue." The redundancy of the steps and that the name of each step is an odd number suggests the name of Redundant, Odd Steps EPMcreate (ROSEPMcreate) for the new technique.

TABLE I. THE 16 STEPS OF EPMCREATE

Step #	Logical Combination	Venn Diagram	Interpretation (Rs=requirements, SH=stakeholder, VP=viewpoint)
0	contradiction		Blank out your mind.
1	VP1 and VP2		Identify Rs inside both VPs.
2	VP1 and (not VP2)		Identify Rs inside the VP of SH1 but outside the VP of SH2.
3	VP1		Identify Rs inside the VP of SH1.
4	(not VP1) and VP2		Identify Rs inside the VP of SH2 but outside the VP of SH1.
5	VP2		Identify Rs inside the VP of SH2.
6	(VP1 and (not VP2)) or ((not VP1) and VP2)		Identify Rs either inside the VP of SH1 or inside the VP of SH2 (but not both).
7	VP1 or VP2		Identify Rs inside the VP of SH1 or the VP of SH2
8	(not VP1) and (not VP2)		Identify Rs outside both VPs.
9	(VP1 and VP2) or ((not VP1) and (not VP2))		Identify Rs inside both VPs or outside both VPs.
10	not VP2		Identify Rs outside the VP of SH2.
11	VP1 or (not VP2)		Identify Rs inside the VP of SH1 or outside the VP of SH2.
12	not VP1		Identify Rs outside the VP of SH1.
13	(not VP1) or VP2		Identify Rs inside the VP of SH2 or outside the VP of SH1.
14	not (VP1 and VP2)		Identify Rs outside the VP of SH1 or outside the VP of SH2.
15	tautology		Identify any Rs that come to your mind.

B. *Experiment design and execution*

The experiment participants were asked to look for requirements to design a meeting planner system. The chosen system fulfills two main needs: being simple enough (1) to not require deep domain knowledge and (2) to allow running the entire experiment during a single lecture slot.

We avoided naming a specific product to avoid influencing the results of the experiment.

In the experiment, the two stakeholder groups were defined to be:

- SH1 = the organizer of a meeting
- SH2 = a participant of the meeting being organized.

The four steps for POEPMcreate were described to the participants as:

1. Please find requirements that are needed by SH1 as well as by SH2.
2. Please find requirements that are needed by SH1, but not by SH2.
3. Please find requirements that are needed by SH2, but not by SH1.
4. Please find requirements that are needed neither by SH1 nor by SH2.

The four steps for ROSEPMcreate were described to the participants as:

1. Please find requirements that are needed by SH1.
2. Please find requirements that are needed by SH2.
3. Please find requirements that are needed by either SH2, SH1, or both.
4. Please find requirements, independent of whether they are needed by anyone.

The experiment was conducted at the Hochschule für Technik in Stuttgart (HFT, <https://www.hft-stuttgart.de>) during the course "Software Project Management". The students were studying business informatics in the second year and can be considered as playing the role of end users. They had no specific requirements engineering training before, but knew the meeting planning problem from their having had to arrange group meeting times to carry out their group assignments in their courses.

The 22 students were assigned to 11 two-person teams by distributing cards effectively saying "Pa", "Pb", "Ra", "Rb", etc. (with "P" or "R" naming the team's technique, POEPMcreate or ROSEPMcreate, respectively, and the small letter uniquely naming the team) randomly to the students. Each team applied its technique's four steps in the specified order and did each step for 10 minutes, for a total of 40 minutes. Each team was given two short questionnaires after finishing the last step. The first questionnaire asked the team to self-evaluate the requirements it had generated and the learnability of its technique. The second questionnaire gathered data about ages, the years of experience in software development, and native languages of the team's members, to allow us to check if these characteristics affected the results of the experiment.

During the experiment, the students were all in the same room, but the room was big enough that they did not disturb each other. The experiment was executed as a pen-and-paper exercise, with enough questionnaires having been printed out. Doing the experiment online to allow quicker analysis would have added technical risks and a source of distraction to the students while not adding any creativity support. Altogether, the experiment lasted 60 minutes.

C. *Instructions to the team and the questionnaires*

The instructions given to the participants were the following (translated from the original instructions in German, the language of the course):

> *Your task consists in identifying requirements for software which supports organizing meetings. These requirements can describe functionalities, but also non-functional requirements, or concern the graphical design or technical properties. Please, try to be as creative as possible, i.e,. to develop new ideas.*

Each team was then asked to apply the steps of its assigned technique, using the description of its four steps given in Section III.B and Venn diagrams like the one in Fig. 1.

The last page of experiment sheet gave the questionnaires shown in Tables II and III. In addition to the tables, there was a free-text field, in which the team could add any further comment it had.

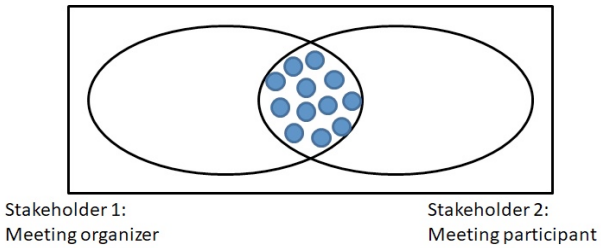

Figure 1. Graphical visualization of Step 1 of POEPMcreate: Requirements that both SH1 and SH2 need.

TABLE II. OPINION QUESTIONNAIRE (TRANSLATED FROM GERMAN)

	No	**Rather no**	**Partly**	**Rather yes**	**Yes**
Do you believe that your requirements are complete?					
Do you believe that your requirements are innovative?					
Did you find the technique easy to apply?					

TABLE III. PERSONAL PROFILE QUESTIONNAIRE

	Participant 1	**Participant 2**
How old are you (in years)?		
Do you already have work experi-ence in the software domain? (yes/no)		
What is your mother language?		

IV. EXPERIMENT RESULTS

A. Data analysis

The resulting requirements and other data from the questionnaires were typed into a spreadsheet. The requirements for all teams were merged and then were sorted alphabetically, in order to help us find repeated requirements. When we found a set of repetitions of the same requirement, as some were better worded, we chose the one with the clearest wording to be the primary requirement, with the others being considered just duplicates. Also, having a merged list of requirements allowed the authors to evaluate the requirements in an unbiased way without knowing which team, and which technique, generated it.

B. Participants profile

The teams are profiled in Table IV. The teams with only native speakers of German are Pb, Pd, Pe, Rb, and Rc. The teams with two non-native speakers each are Pf, Rd and Re. However, the language should not be relevant, as all the students speak German fluently and sufficiently well to study in this language. The teams with participants who have work experience are Ra, Rb, and Rc. Because of the low numbers involved, no test of significance is applicable. Therefore, it's safe to say that there was no significant difference between the teams with only native speakers and the teams with non-native speakers in terms of the numbers of requirements generated.

C. Numbers of requirements

All told, 282 requirements were found. Among them were 230 functional requirements and 52 non-functional requirements. After identifying 135 duplicates, 147 individual requirements were left. Of these 147, 116 were functional requirements and 31 non-functional. The number of duplicates seems low if we consider that a meeting planner is not an exotic tool.

D. Numbers of requirements per team, technique, and step

Tables V and VI show the numbers of requirements that each team generated in each step. For each technique, we can see that (1) the teams overall and (2) all but one team found more requirements in Steps 1 and 2 than in Steps 3 and 4. This difference is more pronounced for ROSEPMcreate than for POEPMcreate, and is not surprising, as ROSEPMcreate includes redundancies, i.e. each step asks for requirements for viewpoints that are covered partially by other steps.

TABLE IV. PROFILE OF THE TEAMS

	Teams Pa to Pf POEPMcreate	**Teams Ra to Re ROSEPMcreate**
Number of participants	12	10
Average age in years	24.3	22.9
Number of participants with work experience in the software domain	0	4
Number of participants whose mother language is German	8	5

TABLE V. NUMBERS OF REQUIREMENTS GENERATED PER TEAM AND STEP WITH POEPMCREATE

Team/ Step	**Pa**	**Pb**	**Pc**	**Pd**	**Pe**	**Pf**	**Total**	**#/ team**
1	10	11	9	6	12	5	53	8.833
2	9	9	9	5	8	5	45	7.500
3	3	2	4	6	8	6	29	4.833
4	1	3	6	3	5	6	24	4.000
Total	23	25	28	20	33	22	151	25.17

TABLE VI. NUMBERS OF REQUIREMENTS GENERATED PER TEAM AND STEP WITH ROSEPMCREATE

Team/ Step	**Ra**	**Rb**	**Rc**	**Rd**	**Re**	**Total**	**#/ team**
1	13	15	11	9	8	56	11.2
2	8	16	6	6	7	43	8.6
3	1	9	0	3	1	14	2.8
4	2	8	0	1	7	18	3.6
Total	24	48	17	19	23	131	26.2

The differences among the teams using any one technique are large. For either technique, the most productive team generated twice as many requirements than the least productive team. ROSEPMcreate teams generated slightly more requirements than PO-EPMcreate teams. However, comparing the teams, the steps, and the techniques with respect to the numbers of requirements, no difference was found to be statistically significant, using a χ^2-test with a significance level of 95%.

These results suggest that ROSEPMcreate is feasible and that it is at least as effective as POEPMcreate.

E. Kano categories

To investigate the innovativeness of the requirements, we categorized them by applying to them the Kano categorization [13], which distinguishes three different categories of requirements, according to the users' expectations and the state of the art:

- Basic requirements: When these requirements are satisfied, it is indifferent to the customer, because they expect them to be satisfied. When these requirements are not satisfied, however, the customers are extremely dissatisfied and the product is not useful.
- Performance requirements: The better these are satisfied, the more the customer is satisfied.
- Delighters: These are product characteristics that are not required and are thus unexpected. Therefore, if they are missing, the customer is not dissatisfied, but if they are realized, the customer is positively excited.

By discussing and comparing the requirements to a known meeting planner, the first two authors determined by consensus, from the merged list of generated requirements, the number of basic requirements and delighters. Not count-

ing duplicates, among the requirements, there were 54 basic requirements, 47 performance requirements, and 38 delighters. It is interesting to see which of the two techniques was producing more innovative, non-basic, non-performance requirements. We assume that generating a basic or performance requirement that an application usually has is not very creative. A creativity technique should support the stakeholders in generating delighters. Therefore, we asked which technique better supported generating delighters. Table VII presents the results of this analysis. POEPMcreate generated slightly more delighter requirements than did ROSEPMcreate. However, according to a $\chi 2$-test at a significance level of 95%, the difference between POEPMcreate's and ROSEPMcreate's distributions of the requirements among the Kano categories is not statistically significant.

F. Stakeholder perspectives

Each requirement was classified also according to the stakeholder for which it is relevant. Not counting the duplicates, there were 44 requirements for only SH1, 38 for only SH2, 55 for both, and 9 for neither. This information can be used to judge whether the teams really focused on the viewpoint combination defined for each step.

For each step and each technique, it was calculated the percentage of the generated requirements belonged to the viewpoint combination for the step specified by the technique. The results, shown in Table VIII, highlight that it was not easy for the teams to generate requirements that corresponded exactly to the viewpoint combination defined for any step. In some steps, only 50% of the requirements belonged to the proper viewpoint combination. The average percentage of requirements belonging to the correct viewpoint combination was 71.7% for POEPMcreate and 75.6% for ROSEPMcreate. It is logical that ROSEPMcreate rates better because its Steps 3 and 4 gather the requirements of several perspectives at the same time.

TABLE VII. NUMBERS OF REQUIREMENTS, CATEGORIZED ACCORDING TO THE KANO CATEGORIES. GIVEN ARE THE ABSOLUTE NUMBERS (IN BRACKETS: PERCENTAGE AMONG ALL REQUIREMENTS)

Kano category	Among all Rs	All Rs, not counting duplicates	With POEPMcreate	With ROSEPMcreate
Basic Rs	121 (44.0%)	54 (38.8%)	60 (41.7%)	61 (46.6%)
Performance Rs	79 (28.7%)	47 (33.8%)	43 (29.9%)	36 (27.5%)
Delighters	75 (27.3%)	38 (27.3%)	41 (28.5%)	34 (26.0%)

TABLE VIII. PERCENTAGE OF REQUIREMENTS BELONGING TO THE CORRECT VIEWPOINT COMBINATION PER STEP

Step	POEPMcreate: Percentage of requirements belonging to the correct viewpoint combination	ROSEPMcreate: Percentage of requirements belonging to the correct viewpoint combination
Step 1	71.5	51.8
Step 2	63.9	50.7
Step 3	81.9	100
Step 4	69.4	100
Average	71.7	75.6

G. Opinion questions

The team participants were also asked to judge the techniques they applied.

Completeness: Table IX shows that the teams, in general do not believe that their requirements are complete. Teams applying ROSEPMcreate are even more pessimistic than teams applying POEPMcreate, although their method includes redundancies and therefore should lead to more complete requirements sets. In fact, teams applying ROSEPMcreate generated slightly more non-duplicate requirements than did those applying POEPMcreate. Because of the low numbers involved, no test for statistical significance is applicable. So, it's safe to say that this difference is not statistically significant.

1) Innovativeness of the requirements: The same table shows that the teams, in general, also do not believe that their requirements are innovative. Teams applying POEPMcreate are even more pessimistic than teams applying ROSEPMcreate. This difference is interesting, because teams applying POEPMcreate generated a higher percentage of delighter requirements than did teams applying ROSEPMcreate.

2) Ease of use of the method: On average, each team found its technique rather easy to use, with no significant differences between the two techniques.

V. THREATS TO VALIDITY

The results of the 6 teams applying POEPMcreate and of the 5 teams applying ROSEPMcreate vary a lot. Therefore, the statistical significance and the statistical power of the results are low. Therefore, the differences observed between the two techniques, although easy to explain, cannot be confirmed to be statistically significant. Some might consider that the participants' being instructed to be creative to be a threat in that it affects the behavior of the participants in applying the techniques. However, since the techniques are creativity techniques, this effect is desired for both techniques. Thus, no one technique obtained any advantage over the other.

TABLE IX. TEAM ANSWERS TO OPINION QUESTIONS

	POEPMcreate					ROSEPMcreate				
	NO(-2)	***Rather NO (-1)***	***Partly (0)***	***Rather yes (1)***	***Yes (2)***	***NO (-2)***	***Rather NO (-1)***	***Partly (0)***	***Rather yes (1)***	***Yes (2)***
Do you believe that your requirements are complete?		4		1	1	1	2	1	1	
Do you believe that your requirements are innovative?		2	4	1			2	2		1
Did you find the method easy to apply?		1	1	2	3			1	3	1

Also, the standard instructions for many creativity techniques includes the exhortation to be creative.Tables V and VI show that in each technique, Steps 3 and 4 generate fewer requirements than Steps 1 and 2. Also, Table VIII shows that in each technique, Steps 1 and 2 generate requirements that do not belong to the right stakeholders. These observations together suggest that the techniques were not applied as expected and that the student participants found it difficult to withhold requirements not belonging to the perspective defined for this step. This possibility needs to be explored in future work.

The teams applying POEPMcreate are not equivalent to the teams applying ROSEPMcreate. There are the following differences:

- Teams Pa through Pf include more native speakers. Trying to be creative in a foreign language does not necessarily mean that one creates fewer ideas, but it is probably more difficult to write them down, and therefore some ideas might not be noted down at all.
- Participants applying POEPMcreate on average are 1.4 years older than those applying ROSEPMcreate.
- In Teams Ra through Re, 4 out of 10 participants have work experience in the software domain, while in Teams Pa through Pf, there is no participant with such experience.

These differences might have influenced the results, both in the numbers of requirements generated and in the teams' perceptions of the techniques applied.

Finally, there is the standard threat of having used students as participants rather than professional analysts. However, nowadays, it is reasonable to expect that all university students have had experience with meeting planners, brainstorming, and being creative. Thus, this experiment did not demand of the participants more than what they already knew, and the participants can be considered as being representative of end users of a meeting planner.

VI. CONCLUSION

EPMcreate assumes that a requirements idea generation session follows 16 steps during which the analysts generate requirements ideas by focusing on all 16 combinations of two stakeholders' viewpoint. The need of a lighter weight creativity process requiring fewer steps led first to the development of POEPMcreate, including only the 4 steps that cover the disjoint 4 regions of the 2-variable Venn diagram. This paper describes an experiment designed to test the effectiveness of ROSEPMcreate, another variant of EPMcreate, based on a different set of 4 steps covering the same regions with some redundancy.

The results of the experiment, even if preliminary, seem to indicate that ROSEPMcreate is at least as feasible and as effective as POEPMcreate. Since previous experiments [8], [10] have already established the feasibility and effectiveness of POEPMcreate, this experiment in effect, establishes the feasibility and effectiveness of ROSEPMcreate in helping to generate requirement ideas.

The experiment results show also that changing viewpoint combinations when applying POEPMcreate or ROSEPMcreate helps generate requirement ideas. With each change, the teams generated additional requirements. However, a generated requirement did not always belong to the viewpoint combination of the step generating the requirement.

The paper also offers Kano categories as a new way to evaluate the innovativeness of generated requirement ideas. Therefore, it is possible to say that the techniques helped the teams also to generate innovative requirements, the delighters in the Kano categorization. About 27% of the requirements generated were delighters. We think this 27% is a good percentage; after all, delighters are, by their very nature, rare.

More experiments are needed to confirm these results and to better understand which one of the techniques is easier to apply. Future work should be focused on the factors that determine the success of a given technique; among them, (a) the suggestion of making explicit the classes of stakeholders; (b) the ordering of the steps; (c) the presence of redundancies in the viewpoint combinations, i.e., overlapping Venn diagram regions for multiple steps, as happens with ROSEPMcreate: the viewpoint combinations for Steps 3 and 5 both include requirements in the viewpoints of both stakeholders; Step 7 covers all the regions already covered in Steps 3 and 5; Step 15 covers all the regions covered by Steps 3, 5, and 7.

The teams found the techniques easy to use, but were pessimistic about completeness and innovativeness of the requirements they generated.

Another relevant issue to be investigated is the usability of the techniques, and in particular on the perception of the ease of use as a function of characteristics of the participants.

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