Making a Causal Contextualization with the Four Causes of Aristotle

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Abstract

This article presents an empirical study which proposes a chained contextualization based on the four causes of Aristotle: material, formal, moving and final ones. This contextualization is a causal one, dedicated to help an analyst looking for root causes of a problem or an unwanted event. It consists of four different chains of causes beginning by the problem or the event and ending by root causes. A "why" question is asked at each step of questioning. Two examples are studied: "Why is this part brittle?" and "Why is this valve opened?". An Aristotelian causal contextualization aims at helping an analyst to deepen the chains of causes and to extend the range of causes which can be identified with a traditional method. Then, the first main interest of an Aristotelian causal contextualization is to help an analyst to see, during an interview, the field of responses of the interviewee and to detect responses which stay on the same "plateau" of explanation (reformulations of symptoms or causes, or description of different steps of an activity). Moreover, since the Aristotelian causal contextualization permits to see the kind of field of causality which is used by an interviewee, it is possible to guide him more easily in other fields of causality by using appropriate questions related to other fields of responses. It is the second main interest of this contextualization.

Keywords causality, Aristotle, contextualization, root cause

1 Introduction

A communication related to an approach of contextualization, based on a musical metaphor (the concept of systemic score), was presented at the 7th congress of EUS in 2008 [1]. The four causes of Aristotle [2-5] were used and grouped in a disc-shaped which was named a note. In this article, the four causes of Aristotle, still grouped as a note, are also used, but to present a chained contextualization aimed at helping an analyst looking for root causes of a problem or an unwanted event. This contextualization consists of different chains of causes beginning by a problem or an event, occurring in a working situation of an industrial company, and ending by root causes.

The root causes are defined as causes that condition the occurrence of more direct causes of a problem or an unwanted event. They are more general than direct causes. It means that the work on a root cause may lead to a larger variety of effects than the work on a direct cause.

The general purpose of this article is to discuss the interest of this causal con-

textualization. Then, the first part will present how to take place an Aristotelian causal contextualization. Secondly, two examples of this contextualization will be proposed and finally a discussion will be presented.

2 How Does a Causal Contextualization Using the Four Causes of Aristotle Take Place ?

2.1 An Aristotelian note and the four causes

In the concept of systemic score, a note is represented as a disc-shaped set of the four causes of Aristotle [1].
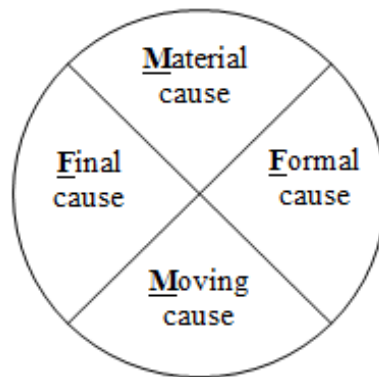
Fig.1 Representation of the four causes as an "Aristotelian note"

The description of the different blocks is as below.

The material causes represent the components of a system.

The formal causes represent the principles of functioning of the system (which explain also its shape).

The moving causes represent the actors dedicated to the process of designing and managing the system. According to Aristotle, the notion of movement is more general than the notion that is considered nowadays (which is only related to kinematic). In this way, the aging of a person is for example a movement too.

The final causes represent the purposes which are aimed by the system.

Then, if the system is for example a car:

- the material causes represent the components of the car: the body, the engine, the wheels, the tyres...;

- the formal causes represent the principles of functioning: the propulsion of the car resulting from the movement of the four wheels on the ground...;

- the moving causes represent the build of the car by the manufacturer and the way of driving and maintaining the car by its driver(s) (indeed that strongly explains also the state of the car...);

- the final causes represent for what uses the car was designed and also the current uses of the car by the driver(s): to transport people, goods... in a sportive way or not, just in town or not?

2.2   Principles and pratical aspects of contextualization

In the present contextualization, the process for identifying the causes is based on "Why" questions. The four causes are used to answer, in four different ways, questions which begin by "Why".

For example, with a question like: "Why is this car red ?", the four responses may be:

- because a red paint is on the body of the car (material cause);

- because a red color is emitted by the painting of the body of the car (formal cause);

- because somebody painted the car in red (moving cause);

- because the manufacturer wanted to enjoy the buyer (final cause).

In this paper, the two initial "Why" questions of the two examples (cf. §3), which will permit to start the contextualization, are "Why is this part brittle ?" and "Why is this valve opened ?". Then, it means that the system which is firstly considered, to start the contextualization, is a local one: a working situation in a company for example. Afterwards, for moving and final causes, a more general system is progressively considered to point out more general causes.

In practice, an Aristotelian causal contextualization is supported by a process of iterative question-answer which starts with an Aristotelian note. New notes are built from each of the four causes, hence the previous denomination.

The contextualization starts with a question which begins by "Why". The first answer is represented as an Aristotelian note, whose the four parts are filled in, i.e. a set of four responses which correspond to the four parts of the note. Afterwards, a new question (which still begins by "Why") built from each previous response is asked. The four new answers are also represented as Aristotelian notes but just one part of these notes is filled in. The part dedicated to one cause is related to the same part of the previous note which is considered. This general process is repeated several times.

To find the responses, a specific "connector" is used for each kind of previous responses. Thus, this contextualization works with keys of questioning to go

back step by step to root causes. A connector is a set of few words which begins by "because", introduces a response and connects each kind of response to the "Why" question.

Then, to contextualize, it is used iteratively the connector:

- "because it consists of ..." for the "material causes" (an analytical approach);

- "because there is/are ... (the principle of functioning of this phenomenon)" for the "formal causes";

- "because there was... (a project manager of it)" for the "moving causes";

- "because the project manager wanted to..." for the "final causes".

The connector "because the project manager wanted to..." was preferred rather than "in order to" for the final causes since the focus is here on the process inside a company and the decisions which were taken. Then, the notion of project manager was introduced since this function is very common in a lot of companies (and besides it is often a part of the job of a manager). For the moving causes, the focus is also on the role of the project manager of the system since the purpose is to present the root causes on which it can be acted on. Indeed, the designer of the current system is generally not still present in the plant. In this way, as Aristotle suggested, there are a lot of relationships between moving cause and final cause (hence the curved dotted lines in the two examples below).

3   Examples of Contextualization

The first question which is considered is: Why is this part brittle? The second one is: Why is this valve opened? These two questions are "Why" questions, respectively related to a problem or an unwanted event.

In these examples, the problem or the unwanted event are related to the occurrence of decision failures. It means that, for instance, an operator did not use the right procedure... Considering the part, which is brittle, there was a dysfunction in the process of making it, since the part ought to be resistant to breaking. Furthermore, there was no sabotage (otherwise the final chain of causes would be different). Considering the activity of closing the valve in a room of a plant, there is an unwanted event since the valve ought to be closed.

3.1   Why is this part brittle ?

The responses of this question is in the middle of the figure 2 and the other answers are built from these previous ones (look at the arrows).

For example, to find the first response of "Why is this part brittle?" in the "material causes" axis, an interviewee may use the connector "because it consists

of" to find the response "Brittle matters". Afterwards, during an interview, an analyst has to ask "Why" and to propose that the interviewee uses again the same connector for the same axis or another one for the other axis.
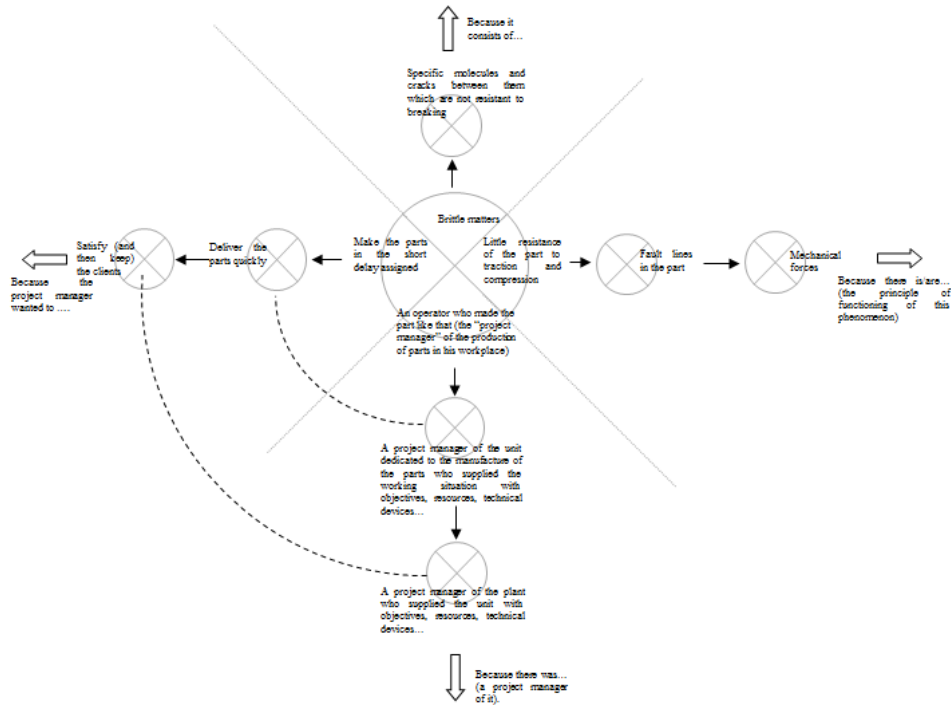

Fig.2 Example of an Aristotelian causal contextualization

3.2   Why is this valve opened ?

The responses of this question are in the middle of the figure 3 and the other answers are built from these previous ones (look at the arrows). The valve is a butterfly valve which is manually opened and closed. It consists of a core and a disc which rotates around an axis and there is generally a fluid in the pipe when the valve is opened.

3.3   Some remarks about the contextualization

1) Representation of an Aristotelian causal contextualization

   In the two examples, only one chain of Aristotelian notes was presented in each field of causality. Other chains of notes could be carried out with the same answer-formulation. For example, it could be possible to go back to root material causes from each components and afterwards sub-components of the system. Nevertheless, our objective is not to propose another method of determination

of root causes. It is to discuss the interests of this kind of contextualization to help the analyst when he carries out a fact gathering and uses methods, like, for example, the 5 Whys [6-7] or the causal tree analysis [8].
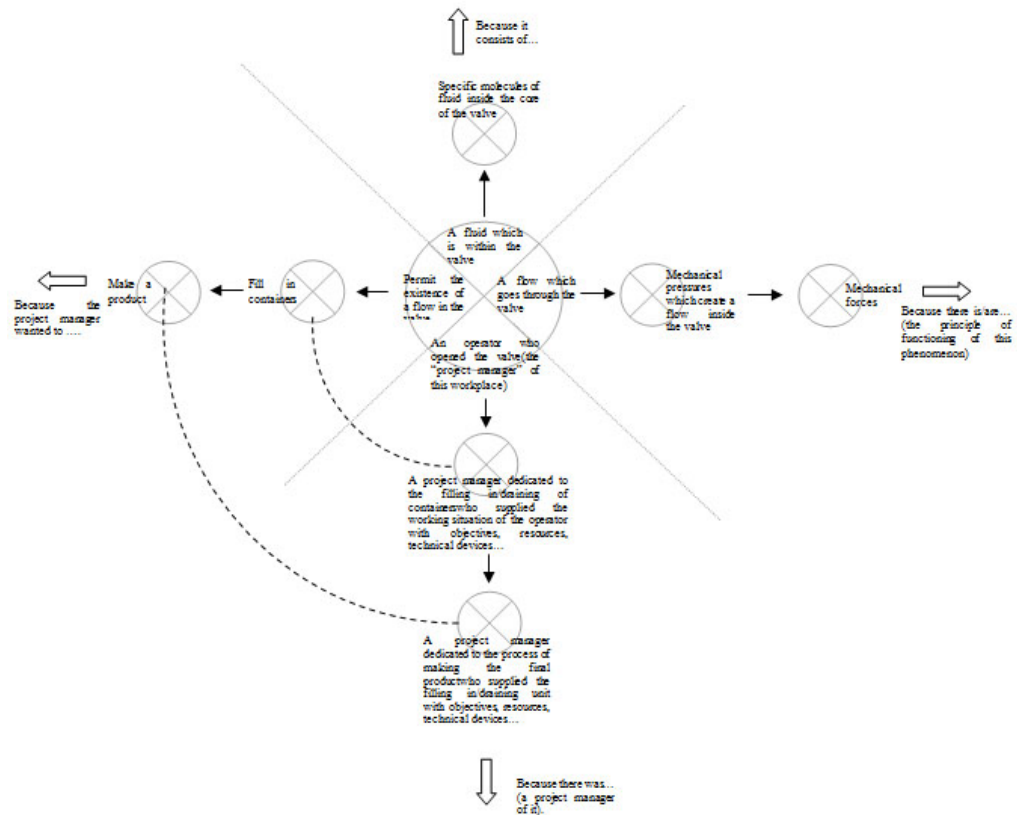

Fig.3 Example of an Aristotelian causal contextualization

2) Expression of the moving and final causes

The focus was on two kinds of examples which are related to two domains: quality and safety. In the first one, the notion of quality, as a result [9], may be evaluated in terms of scope (of the product), cost and time/duration (to obtain the product) [10]. It is why the final causes are indicated with one objective and one or two characteristics of it (in terms of scope, cost or time/duration) which may mainly contribute to explain the occurrence of the problem (of quality). Concerning safety, it is not provided, for final causes, characterizations of an objective in terms of scope, cost or duration. Indeed, "to be opened" is not, for the valve which is considered, a defect by itself (sometimes the application of the procedures leads to open it). On the contrary, "to be brittle" is, for the part of

the first example, a defect by itself (it is never a quality for it). It is why it is necessary to add some characteristic in terms of scope, cost or time/duration. Note that for other things like for example some kind of cakes, "to be brittle" is a quality...

In our context of looking for the root causes, it was considered that "to be brittle" or "to be opened" are respectively a problem or an unwanted event. For the part, it could have been related to some problems concerning raw materials used to make it. But, in this case, the final causes would have been different. It means that, in the two examples, operators made mistakes. More precisely, these mistakes are rule-based or knowledge-based errors [11]:

- rule-based error: for example, an operator opened the valve instead of keeping it closed. He did not analyze correctly the situation and then did not use the right procedure;

- knowledge-based error: in this case, the operator did not know he had to close the valve to achieve this operation.

A skill-based error (for example an operator wanted to close the valve but he kept the valve opened: it was a slip) may be here considered only for the part since in our example the operator wanted to open the valve.

The explanation of the occurrence of the human failures comes from the examination of the moving causes. In this axis, the explanation of the problem, the unwanted event or a direct moving causes results from the lack of adaptation between four sets of factors: local work organization, team and competences, technical devices and work environment (like premises, noise) which can be identified in each root moving causes. These groups of factors appear in the classical methods using "why" questions or in Human and Organizational Factors methods. The Aristotelian causal contextualization proposes here a framework to locate these factors in the working situation, the unit or the plant. The factors are very similar to those which can be found in a MTO approach (Man, Technology, Organization) [12]. Then, in a few words, if there is a mistake in the operation which is considered, the explanation (the lack of interaction between the previous factors) is found in the moving causes which are identified.

4   Discussion: Interests of this Aristotelian Causal Contextualization to Help an Analyst

Even if more examples would be necessary to confirm these main findings, here are some first elements. Two points are proposed:
- deepen the chains of causes,
and
- extend the range of causes.

4.1   Deepen the chains of causes

After the occurrence of a problem, an unwanted event the first step of an analysis is generally to carry out a fact gathering. It is often the step before an iterative question-answer session using a more or less complicated "Why" question to find root causes and then to identify chains of causes that explain the occurrence of the event, the problem⋯ Afterwards, the objective is to propose solutions to remove the root causes.

Nevertheless, sometimes analysts may not really go back to root causes, even if there is a presentation of different causal chains in the analysis. In fact, there may be a treadmill effect at one or several levels of explanation of the event or the problem. There is a "plateau" in which, for example, it may be found reformulations or descriptions of different steps of a human activity or a mistake. It could partly explain that analysts may just consider the symptoms or very direct causes. It means also that the number of question-answer is not a sufficient criterion to provide an in-depth analysis and to find the real root causes.

This problem may be observed especially when the focus is on the material or formal fields of causality. Two phenomena may be mainly described:

- concerning the material causality, the evocation of a succession of steps of the activity of an operator instead of detailing one step into sub-steps... (for example a detailing process would be: make a mistake / press the wrong button / push the button A with one finger / push of 0.5 cm on the button A)

- concerning the formal causality, the reformulation of the cause instead of going back to a more general principle of explanation (for a mistake for example, a more general principle indicates the type of mistake and afterwards the type of characterization of the mistake...: make a mistake / realize an operation in a different way that is assigned / consider the results of the activity to evoke the mistake)

To go back really to root causes, in the material causality and formal causality fields (cf. the two examples of §3), it is necessary to identify, at each step of questioning (with a "Why" question), respectively, the basic components and the general principle of functioning (which underlies the previous formal cause which is considered).

1) Material causality: succession of elements as some steps of the activity of a person

Here is an example which illustrates this phenomenon of treadmill effect:

"Why did he press the wrong button? Because he confused the two buttons

Why did he confuse the two buttons? Because he had a wrong mental representation

Why did he have a wrong representation? Because he did not analyze correctly the working situation

Why did he not analyze correctly the working situation? Because he did not detect the pertinent information"

In this succession of question-answer, the focus is on a mistake. First of all, the movement of a finger of the operator is evoked, next some dysfunctions of the mental process are explored and, in the end, the problem of perception is considered. In other words, the model of J. Rasmussen [13] is followed in the reverse direction (from execution of action to the perception). Thus, it is taken into account several elements which are just different steps of the mental information processing and execution of action!

2) Formal causality: some kinds of reformulation

• Example 1: going from action (or human failure) to emotion and vice versa

"Why did he move these objects nervously? Because he was angry"

Or (in the opposite way)

"Why was he happy? Because he was watching the sun set over the sea"

• Example 2: going from an expression of a mistake to another expression of the same mistake

"Why did he make a careless mistake ? Because he did not pay attention"

"Why did he not pay attention ? Because he worked too quickly"

"Why did he work too quickly ? Because he used a mode of thought "System 1" (fast thinking) [14]"

Then, in cases of reformulations or successions of different steps of an activity, the analysts do not go back to root causes. They stand still! This phenomenon seems to occur particularly with material and formal causes.

Thus, the first interest of the Aristotelian causal contextualization is both to help the analyst (during an interview) to see the field of responses of an interviewee and to avoid some current treadmill effect. When the analyst-interviewer detects responses which stay on the same "plateau" of explanation, for example reformulations of symptoms, or direct causes, or the description of different steps of an activity, it means that the interviewee stands still at one level of causality without going back really to root causes.

4.2   Extend the range of causes

A little variety of causes is sometimes taken into account in the analyses [6-7]. It may mean that analysts cannot go beyond their current knowledge about the working situations. The interests of an Aristotelian causal contextualization is to propose four ways of questioning a problem and force the analysts to multiply the points of view. It leads analysts not to focus on a single set of root causes.

The example of §4.1 about material causality, with a 4 Why's iterative questioning, shows that it is easy to stay in the "material causes" field of a mistake without going to another causality field like moving causes. For example, considering the question "Why did he press the wrong button?" the response could

also have been: "because the buttons of displays were too small" or "because he did not know that the procedure had changed". Thus, since the Aristotelian causal contextualization permits to see the kind of field of causality which is used by an interviewee, it is possible to guide him more easily in other fields by using appropriate questions related to the wanted field of responses. For example, if an analyst wants to identify some causal factors related to moving causes, he can turn to questions like "what technical devices or competences are necessary to make this product?" or "what are the objectives of the project manager of the unit?".

In other words, the range of fields proposed by an Aristotelian causal contextualization is very large since, as R. Caratini (2012) [15] indicated, the material and formal causalities are immanent (they depend only on the object) and the moving and final causalities are external. It is an important interest of this kind of formalization to permit to enlarge the set of points of view!

5 Conclusion

An Aristotelian causal contextualization is an implementation of the notion of contextualization [16]. It is a support to identify and categorize the causes of a problem or an event [17-18]. Then, it may be a way to help an analyst looking for root causes.

To end this article, here are some perspectives of works for the future:

- the possibility to distinguish different ways of causality and the existence of specific connectors for each field of causality are perhaps a way to find, in a chain, a "good distance" from one cause to another. Indeed, with a lot of approaches, the different causes may be more or less "distant" one to another. It means that, with these latest approaches, another analyst may often identify an intermediate cause between two successive causes of a chain;

- the use of an Aristotelian causal contextualization aims at completing a common investigation about the root causes. It is perhaps a way to make results more repeatable from one analyst to another (each of them using their own method completed by this Aristotelian contextualization). Do we see the same evolution than the airplane traffic? In this latest domain, the air corridors were created so that all flights can be repeatable... May these air corridors be compared to the 4 causality fields of an Aristotelian causal contextualization?

Then, going back in the past to the basics of Aristotle will be perhaps a way to take a better jump forward!

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