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A closed-loop control for a cooperative innovation culture in interorganizational R&D projects

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Abstract

Since project managers only have a limited authority in interorganizational R&D projects a cooperative innovation culture is essential for team cohesion and thus for achieving project scope in time and cost. For its development different factors depending on underlying values are essential. These factors must be learned iteratively by the project members so that they are living the values of a cooperative innovation culture. Hence, this paper raises the following research question: "How to control living the values of a cooperative innovation culture in interorganizational R&D projects?" To answer this question, a closed-loop control for a cooperative innovation culture is developed. The developed closed-loop control system includes several different functional units which show essential roles and several different variables which show what to consider and design in the control system. In addition, the developed closed-loop control system is generalized for other types of projects such as intraorganizational projects.

Keywords: Closed-loop control; Cooperative innovation culture; Interorganizational projects

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1. Introduction

A high product and technology complexity leads to more and more organizations cooperating in their research and development (R&D) activities [1, 2]. Interorganizational R&D projects result which are temporary organizations [3]. Within these projects heterogeneous organizations work closely together in order to achieve a common goal [4, 5]. Since interorganizational project managers only have a limited authority, a project culture conducive to cooperation and innovation, a cooperative innovation culture, is essential for the collaboration of the project members [4, 5]. Because it strengthens team cohesion through the creation of network-specific cooperation practices and rules of conduct [5].

A culture is the complex and dynamic system of shared basic assumptions, chosen beliefs and values as well as artifacts, that develops in a social system (= game) as self-evident rules of the game over time [5]. Dieterich et al. 2021 show in a two-part model how a cooperative innovation culture as project culture develops and that besides norms, operational and organizational structure as well as behavior of project members especially the underlying values as a basic form of culture (see [6, 7]) are essential in order to develop a cooperative innovation culture in interorganizational R&D projects [5]. These factors are part of the system 'culture' and must be learned iteratively by the project members so that they are living the values of a cooperative innovation culture. Then they can become anchored as its basic assumptions in an interorganizational R&D project [5]. Hence, a continuous control of living the values of a cooperative innovation culture becomes essential. Thus, this paper raises the following research question: "How to control living the values of a cooperative innovation culture in interorganizational R&D projects?"

To answer this research question, a closed-loop control for a cooperative innovation culture is developed based on theoretical basics which are described in section two. The theoretical background comprises basics to a closed-loop control and to a cooperative innovation culture. Based on these basics, in section three a closed-loop control for a cooperative innovation culture in interorganizational R&D projects is developed. In section four it is shown how the developed closed-loop control works in practice. Afterwards, in section five the developed closed-loop control is discussed and then in section six a conclusion, limitations and avenues for future research are given.

2. Theoretical background

2.1. Closed-loop control

According to DIN IEC 60050-351:2014-09 a closed-loop control is a 'process whereby one variable quantity, namely the controlled variable is continuously or sequentially measured, compared with another variable quantity, namely the reference variable, and influenced in such a manner as to adjust to the reference variable' ([8], p.136). A closed-loop control has a closed action path in which the controlled variable constantly influences itself [8]. Fig. 1 shows typical elements of a closed-loop control system.

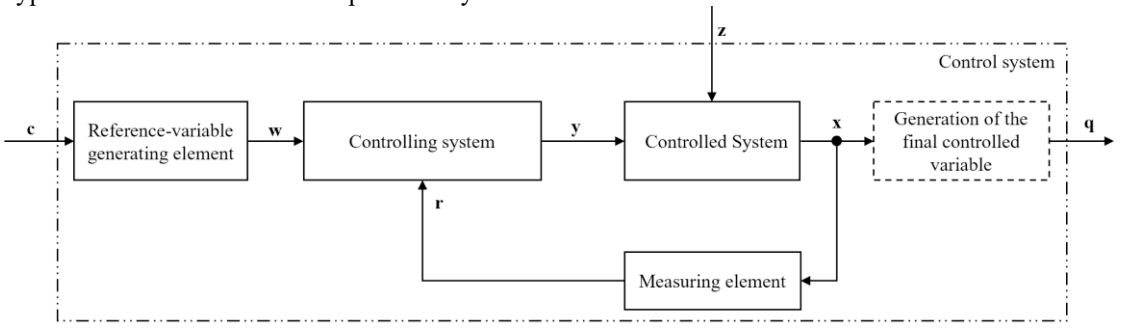

Fig. 1. Typical elements of a closed-loop control system, following [8]

As Fig. 1 shows, a control system consists of a reference-variable generating element, a controlled system, its controlling system and a measuring element. Input of the reference-variable generating element is the command variable (c) which is supplied to the closed-loop control from outside and thus is not influenced by the control. The

final controlled variable (q) should follow it in a given relationship. From the command variable (c) the reference-variable generating element generates the reference variable (w) at its output [8]. The reference variable (w) is the input variable to the controlling system which generates from the reference variable (w) and the feedback variable (r) the manipulated variable (y) at its output. The manipulated variable (y) is the input variable of the controlled system whose output is the controlled variable (x). In accordance with the control task the controlled system is influenced. From the outside a disturbance variable (z) which is an undesired, mostly unpredictable and independent input variable acts on the controlled system [8]. The controlled variable (x) is the input variable of the measuring element which generates the feedback variable (r). Derived from the control task comes the final controlled variable (q) which must be connected functionally with the controlled variable (x). However, it needs not to be part of the closed-loop control [8].

2.2. Cooperative innovation culture

A project culture in interorganizational R&D projects develops through the interplay of the four levels R&D activities, strategic level, operational level and results level [5]. The level of R&D activities comprises the basic research, technology development and predevelopment as well as product and process development (see [9] for more detailed information). Companies or institutions in general can form interorganizational R&D projects for one or more of these activities. Dependent on each activity the outcome of the project has rather a character of a public good (e.g., in basic research) or a private good (e.g., in product and process development) [10]. This influences the project culture development [5]. The strategic level comprises cooperation phases, project phases and project management phases as well as working packages. The cooperation phases can extend over the whole project life cycle or only for some project phases depending on which phases are carried out in cooperation. The strategic level is connected to the operational level via the working packages. Because within each working package problem-solving processes take place [5]. The problem-solving processes are operational work steps belonging to the operational level. Since problem-solving processes are mainly carried out in teams, on an operational level the collaboration levels ‘organization’, ‘relation’ and ‘content’ become essential [5]. The organizational collaboration level can be assigned project organization, connection to the parent organization and procedures. The relational level includes, for example, shaping the relationships, trust, personal communication and project culture [11]. The content-related collaboration level can be assigned, for example, productive work, requirements, time and costs as well as scope which includes, for example, desired project outcomes, quality, vision and goals of a project [11]. The operational level is connected to the results level via the content-related collaboration level. The results level includes, for example, lists of requirements, calculations and sketches [5]. This area of project culture development [5] is illustrated in Fig. 2.

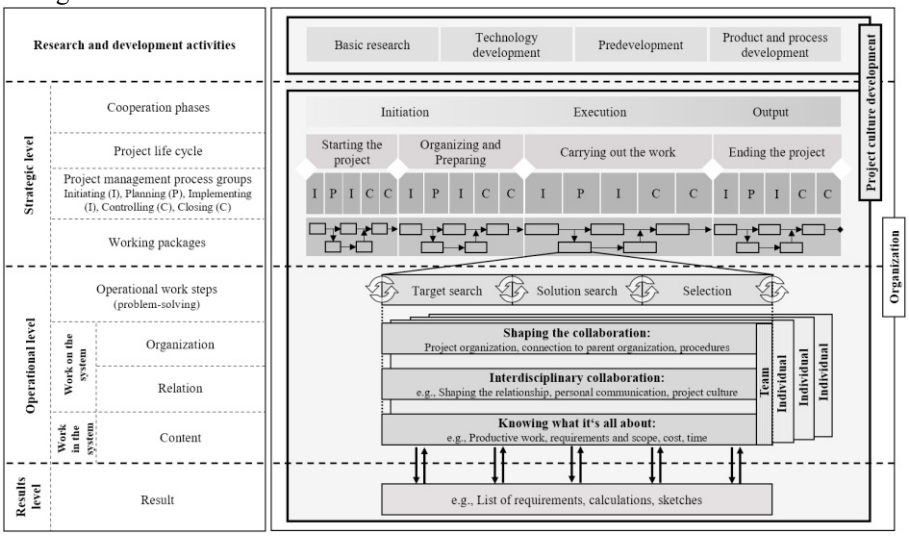

Fig. 2. Area of project culture development, following [5], translated.

A project culture manifests on the relational collaboration level and becomes visible when project members work together. Thus, for influencing project culture so that it is conducive to cooperation and innovation, the creation of conditions for likely cooperative and innovative behavior [5] is essential. According to the adapted reasoned action approach (for more information concerning the reasoned action approach see [12]) for interorganizational R&D projects on an operational level, behavior can be influenced by different background factors of the temporary organization and by different background factors within the temporary organization [5]. The background factors of the temporary organizations are dependent on the respective team member since these are individual factors (e.g., emotion, mood or personality) and person-specific social factors (e.g., age, education or [organizational] culture). Thus, these are difficult to shape in an interorganizational R&D project. Hence, for setting conditions for likely cooperative and innovative behavior the background factors within a temporary organization which are values of a cooperation and of an innovation culture, norms and the operational and organizational project structure need to be considered [5].

Dieterich et al. 2021 show an 'effect chain' on how likely cooperative and innovative behavior can result [5]. This effect chain starts with the underlying values of a cooperation and of an innovation culture. Then, norms follow which give project members concrete rules of conduct and thus an overview on which behavior is welcome. These norms should manifest in project organization. Hence, following the structure follows sequence principle [13], the operational and then the organizational structure is designed [5]. Based on these background factors each team member forms beliefs, and thus an attitude toward the behavior, a perceived norm as well as a perceived behavior control. This leads to trust and an innovative intention and thus to a cooperative and innovative behavior. Values of a cooperation and of an innovation culture and the norms that follow them are chosen beliefs and values. The operational and organizational structure as well as the behavior are visible for the project members and thus artifacts (see [14] for more detailed information on the three levels of culture artifacts, chosen beliefs and values and basic assumptions) [5]. For chosen beliefs and values as well as artifacts the focus is on the interorganizational project (team). By contrast, beliefs, attitudes toward the behavior, perceived norms, perceived behavior controls and intentions are invisible for project members and thus basic assumptions. Hence, the focus is on the individual. Moreover, the individual and person-specific factors are as well basic assumptions since these are the self-evident factors that shape or have shaped the respective persons through their life circumstances [5]. Fig. 3 shows the 'effect chain' for likely cooperative and innovative behavior.

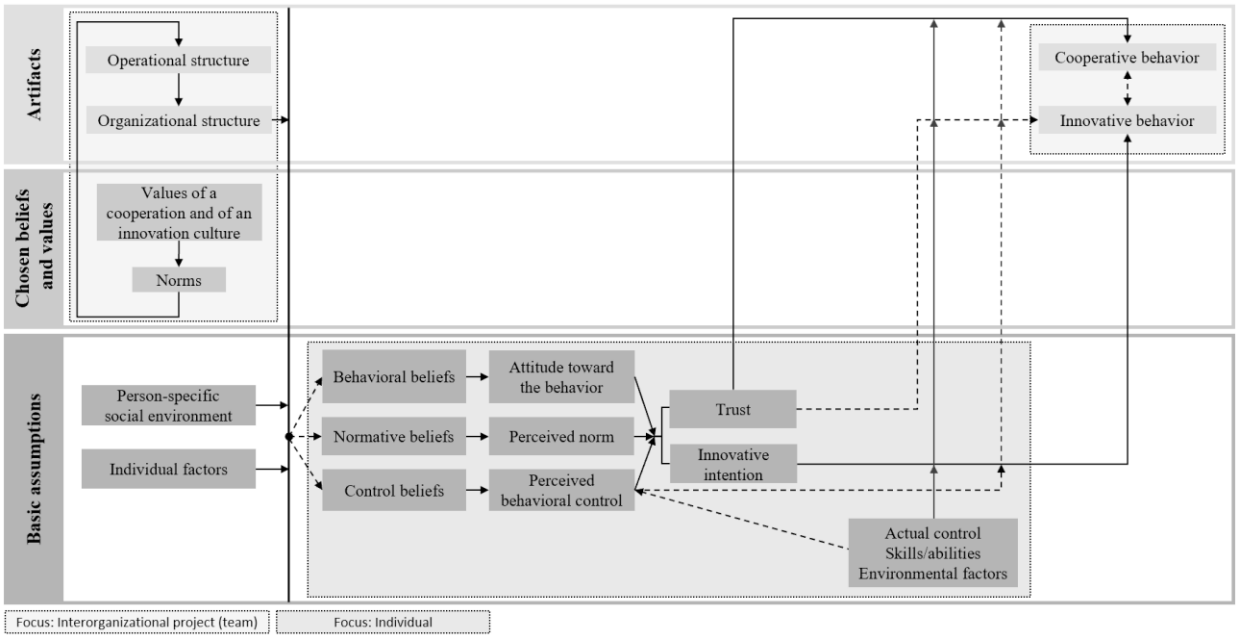

Fig. 3. 'Effect chain' for likely cooperative and innovative behavior, following [5], translated.

3. Closed-loop control for a cooperative innovation culture

For a closed-loop control for a cooperative innovation culture in an interorganizational R&D project, the control system is the cooperative innovation culture. In order to control living the underlying values of a cooperative innovation culture, the variable to be controlled is the behavior of the interorganizational project members according to its values. Thus, the reference variable is the desired behavior according to values of a cooperative innovation culture and the controlled variable is the actual behavior according to its actual values.

The reference variable is generated by the reference-variable generating element whose input is the command variable. The command variable comes from outside the control system and should be with the final controlled variable in a given relationship. Since a cooperative innovation culture is mainly influenced by the project outcomes (see section 2.2) and should support their achievements in time and cost, this command variable is project scope dependent on project time and project cost. With consideration of scope the reference-variable generating element generates a consensus of values of a cooperative innovation culture which determines the desired behavior of the project members. Thus, the reference-variable generating element can be a dialogue conference since this promotes a democratic dialogue between persons of different hierarchical levels and is oriented on the consensus principle [15, 16]. Hence, the output of the dialogue conference is the reference variable which is the desired behavior of the project members according to values of a cooperative innovation culture. This variable is the input variable for the controlling system. Since according to Dieterich et al. 2021 project members should be included in designing the background factors that can influence their behavior [5], the controlling system are the manager(s) and/or the interorganizational project team. Thus, at its output, the manipulating variables are the norms, operational and organizational structure.

Since a cooperative innovation culture manifests itself through interorganizational project members living its underlying values, the interorganizational project members are the controlled system. Disturbance variables act on this system from outside which are for example hidden agendas, hindering instructions of the individual parent organizations or unclear goals. These factors influence the controlled variable which is the actual behavior of the project members according to its actual values. The controlled variable is measured by observer(s) who can or cannot be project member(s). The observed actual behavior is the feedback variable to the manager(s) and/or the interorganizational project team.

From the controlled variable (x) the final controlled variable (q) can be generated. According to Spath 2017 the behavior of organization members needs to be influenced in order to achieve the organization goals flexibility, stability and effectiveness/efficiency [13]. Furthermore, living the values of a cooperative innovation culture strengthens team cohesion through the creation of network-specific cooperation practices and rules of conduct (see [5]) and thus promotes collaboration of the project members which supports achieving project scope in cost and time (see [17]). Hence, the organization goals are the final controlled variables. Fig. 4 shows a closed-loop control for a cooperative innovation culture.

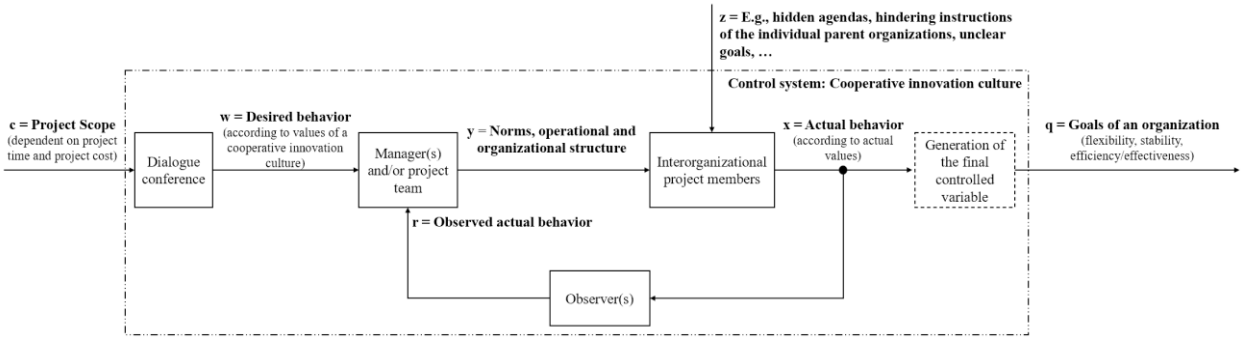

Fig. 4. A closed-loop control for a cooperative innovation culture in interorganizational R&D projects

4. How it works in practice

When starting an interorganizational R&D project, after agreeing on a common project scope, the interorganizational project members of different hierarchical levels organize a dialogue conference. Within this conference they decide in a consensus, which values of a cooperative innovation culture they want to set as valid common values for the interorganizational R&D project. With this decision they define their behavioral benchmark which is valid on each hierarchical level. Then, based on their agreed common value basis the manager(s) and/or the interorganizational project team design their organizational environment. First, they develop norms together, followed by designing the operational and organizational project structure together.

The common value basis and the organizational environment based on it influence the interorganizational project members during their content-related working processes for achieving the project scope. Moreover, they are influenced by their parent organizations. From these, disturbance variables such as hidden agendas, unclear goals or hindering instructions can make it difficult for the interorganizational project members to comply with the common agreed values. Thus, an actual behavior of the project members according to their actual values results. Observer(s) which can or cannot be a part of the interorganizational project observe the actual behavior and feed back their observations about the actual behavior to the manager(s) and/or the project team. With these observations, the manager(s) and/or the interorganizational project team can determine discrepancies between the desired and actual behavior, identify reasons for these discrepancies and thus can adjust norms and/or the operational and/or the organizational structure accordingly. With this process the actual behavior can approach the desired behavior.

Moreover, the actual behavior of the interorganizational project members affects the goals of the temporary organization. Through the process described above, the interorganizational project members form over time shared basic assumptions of a cooperative innovation culture. These can promote team cohesion and thus can be beneficial for the organization goals dependent on the valid common value basis within the interorganizational R&D project.

5. Discussion

To the best of our knowledge this closed-loop control for a cooperative innovation culture is the first approach to control living the values of a culture. This is especially for team cohesion in interorganizational projects essential since project members are heterogeneous and project managers only have a limited authority [4]. Moreover, the acceptance and commitment of the interorganizational project members are increased through the definition of a common value basis and the joint design process of the organizational environment in which every individual team member is contributing [5]. Thus, on the one hand this paper contributes to research on interorganizational projects as there are mainly open research questions to practices and routines, governance and behavior [3]. The developed closed-loop control shows who is involved and which roles are important to consider in controlling the living of values of a cooperative innovation culture. Thus, the understanding of the formation of interorganizational routines and practices can be increased.

On the other hand, this paper contributes to project management research in general as this is to the best of our knowledge the first approach for a closed-loop control of a culture. In projects, a different culture develops than in the parent organization [11]. Thus, setting a value consensus based on which the desired behavior of the project members is communicated also helps intraorganizational project teams to strengthen their team cohesion and achieve their scope in cost and time. Fig. 5 shows a general closed-loop control for project culture.

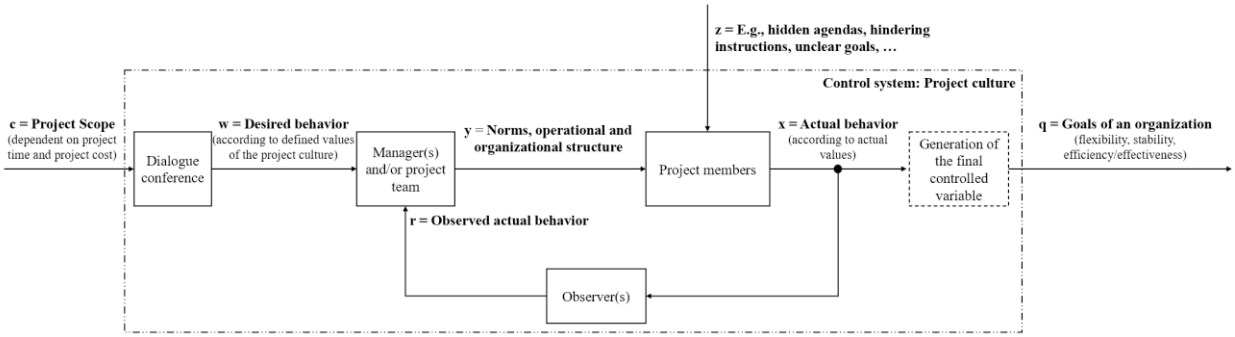

Fig. 5: A general closed-loop control for project culture

With feedback from observer(s), every individual team member can identify reasons for discrepancies between the actual and desired behavior. Based on this identification, the project team can then discuss and minimize the most relevant disturbance variables. Depending on the outcome of the discussion norms and/or the operational and/or the organizational project structure can be adjusted accordingly. Moreover, the definition of the desired values of a project culture in a dialogue conference (see [15]) is beneficial in projects as a democratic dialogue between persons of different hierarchical levels promotes finding a value consensus and increases the commitment of the interorganizational project members. In addition, with a closed-loop control, the sensitivity to a project-culture-aware management (see [5]) is increased and the manager(s) and the project team know their role in it. This type of management is especially essential in the context of understanding culture as a dynamic construct (see [18]).

6. Conclusion, limitations and future research

This paper aims at answering the following research question: “How to control living the values of a cooperative innovation culture in interorganizational R&D projects?”. To answer this research question, a closed-loop control for a cooperative innovation culture is developed based on theoretical basics on a closed-loop control for systems in cybernetics and a cooperative innovation culture in interorganizational R&D projects. It consists of different functional units such as dialogue conferences, manager(s) or project members and of different variables such as the desired behavior according to values of a cooperative innovation culture or the actual behavior according to its actual values. Furthermore, the developed closed-loop control is generalized for other types of projects such as intraorganizational projects.

The developed closed-loop control shows which elements influence a cooperative innovation culture in interorganizational R&D projects. It indicates what different roles should do to promote an approximation of the actual to the desired behavior. Through the definition of a common value basis and the joint design process of the organizational environment, the commitment of the interorganizational project members is increasing. Moreover, the developed closed-loop control sensitizes project members regarding the identification of disturbance variables and supports them in minimizing them. Thus, to sum up, it supports a project-culture-aware management which is especially essential for interorganizational R&D projects.

However, there are also some limitations which need to be considered when using the devleoped closed-loop control. The developed closed-loop control is a simplified representation to control living the values of a culture. Since projects, humans and teams are non-trivial systems, unpredictable reactions can always occur [11]. Furthermore, individual and person-specific factors of project members (see Fig. 3) are not considered in detail. The developed closed-loop control shows important elements for project culture development which is the focus of this paper. This closed-loop control can be integrated in project management systems in order to control and thus achieve an overall project success.

Project-culture-aware management is a promising research direction, especially for interorganizational R&D projects, on which future research should further elaborate on. Therefore, subject of future research should be how the integration described above and an implementation in practice could work. For this, future research could

address how the control difference of desired and actual behavior can be measured and what other reference-variable generating elements could be used besides a dialogue conference.

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