Influence of Task Characteristics on Team Performance

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Abstract –**Although many models of team performance acknowledge the importance of task characteristics and their effects on team outcome, task characteristics have often been neglected in empirical research. Instead, the focus has been on variables regarding internal team processes such as coherence, motivation or coordination and team composition variables. In this paper the effects of task characteristics and team characteristics on team outcome are evaluated empirically. A total of 21 teams participated in a laboratory experiment. Teams were designed as either age homogeneous or age heterogeneous groups while task characteristics were accounted for by requirements. Task requirements differed according to diverse needs for task completion within stages of the innovation process. This was implemented using two tasks which are approximations of the different challenges within the completion of an innovation process. The results show that both, task characteristics and team composition, have significant effects on the outcome of team performance. The evaluation allows an analysis of the impact of team and task factors on service productivity across the whole chain of value creation, e.g. within a complex engineering service setting.**

Keywords – **Service productivity, task characteristics, team composition, team performance**

I. INTRODUCTION

Whether in manufacturing and production environments or in service provision, such as e.g. engineering services, competition between firms becomes more fierce and intensified. A shortening in product life cycles forces the release of new and improved successor products within shorter periods of time. A crucial key for enterprises to stay competitive lies in their capability of being innovative on a constant basis [1]. The dynamic features of market share competition have led to an increased attention on innovation and innovation management.

As a consequence of the transition in the organization of labor, nowadays a majority of tasks are delegated to groups of people. This is especially true for complex task such as product development or engineering services, where knowledge from different fields has to be integrated in order to complete the task successful. However, although most models of team performance acknowledge the importance of task characteristics as a relevant input factor, empirical studies have not covered the type of task as a relevant determinant of team performance extensively. This paper examines the role of both, task characteristics and team characteristics in their effect on team performance within innovative settings.

The paper outline is as follows: first, some theoretical background on innovation, service productivity and team performance is introduced shortly. This serves as the theoretical framework from which hypothesis are derived. The ensuing method section describes the empirical study in detail. The results are presented and discussed. The paper concludes with a summary and an outlook.

A Innovation Management

Although the need for innovation and its management is obvious to scientists and practitioners alike, the study of innovation is tainted with difficulties. The early scientific interest in innovation dates back to the beginning of the 20th century [2]. Since then innovation gained a more prominent role and became a topic of interest not only to economics, but also to other disciplines such as industrial engineering, psychology and organization science. Innovation, its antecedents as well as its consequences for individuals, products, enterprises and markets, are subject to scientific analysis throughout the disciplines. Although no theoretical approach is yet able to make a-priori predictions on the occurrence, failure and success of innovations, post-hoc analysis of completed innovation projects become even more important as they can reveal key features for the successful management of on-going innovation projects. In line with this approach, especially the recognition of different phases of the innovation process had enormous impact on management of innovations. Within the last decades, several models of innovation were developed [e.g. 3, 4]. A common feature to most of these models is that they view innovation as a sequence of activities. One exception to these models is made by Cooper [5], who includes 'decision gates' on whether to continue work on an innovation or not equal to 'go/no-go' decisions. Besides that, this model also assumes innovations follow a sequence of stages. Such process models of innovation have normative characters as they have a highly explanatory value in how innovation processes take place (e.g. with regard to a time component), which actors are involved and what (informatory) dependencies exist between them.

According to its etymology, innovation is the creation of something new or the renewal of something existing. Hence, innovation has some kind of reference point against which it can be compared. The "newness" in many cases relates to either a product or a process. However, sometimes also a service can be the focal point

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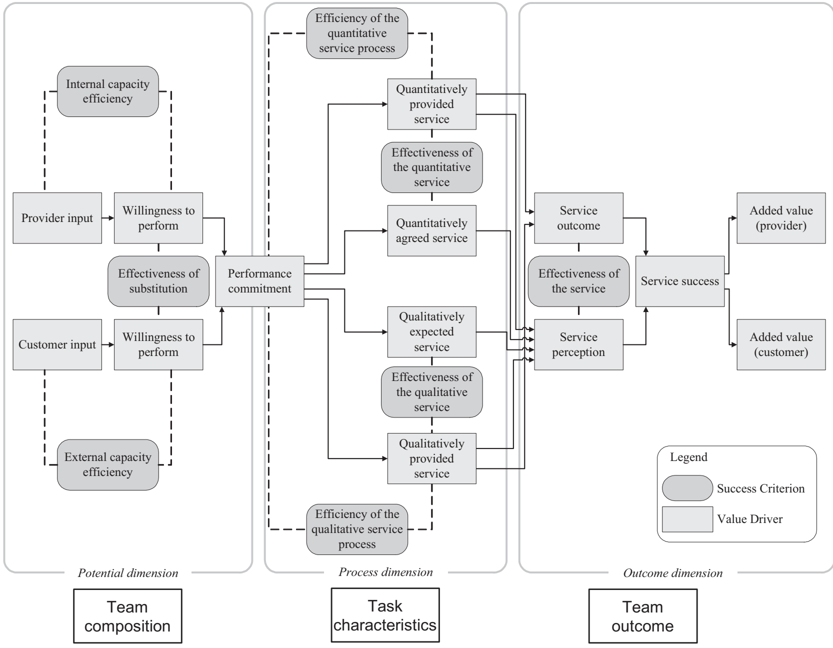

Fig. 1. Service Productivity Model [10] and according team performance variables.

of an innovation. The course of management therefore is dependent on the type of innovation (i.e. product, process or service). The majority of (case) studies on innovation management – and accordingly the majority of innovation process models – has been in the area of new product development. However, research on innovation in the service sector has often been neglected. This becomes even more serious when taking the fact into account that the OECD business tendency statistics are pointing to a decline of production and construction figures over the past decade, while in the meanwhile figures on service provision have increased [6]. However, as traditional innovation process models originate in product development, they are not a suited theoretical starting point for hypothesis deduction.

B Service Productivity

In addition to missing models of service innovation, the well-known concept of productivity from manufacturing cannot be applied within the service domain. Therefore, based on previous models and empirical findings of service provision productivity [e.g. 7, 8, 9], a generic service productivity model focusing on complex engineering services was developed and evaluated in different engineering companies [10]. The productivity model considers the value chain of a single service project and the fundamental approach of the model is laid by dividing service productivity into three dimensions: potential, process and outcome. At the heart of the productivity model are value drivers, which empirically can be captured as performance indicators. Due to the nature of service provision these performance indicators are divided into efficiency and effectiveness criteria. Within the potential dimension, value drivers represent the input factors of service provider and service customer resulting in the joint willingness to perform the service. The transition into the process dimension starts with the commitment of the provider and the customer on the performance. In the process dimension the division into customer and provider is annulled because of the cooperative nature of the process of service provision. The outcome dimension represents the result of the service provision (see Fig. 1).

The ground for a successful complex service project is prepared in the potential dimension. Providing the optimal input factors, both quantitative (e.g. time and budget) and qualitative (e.g. team composition), is essential for project success. During service provision the adequate combination of team processes (e.g. conflict handling) within the process dimension is crucial for positive evaluation in the outcome dimension.

C Team Performance

In fact, similar to the service productivity model, most models of team performance are designed in the same fashion as input – process – output models (IPO – models) [11]. Several team models acknowledge the importance of task characteristics [e.g. 12, 13], yet many empirical studies neglect task characteristics as an explanatory variable. Most studies however mainly apply to highly-structured tasks where team output is defined in a precise manner. The question arises whether the findings can be applied to teams facing innovative, weakly-structured tasks in R&D project environments.

From the pool of possible input and process factors, the age structure of project teams and their effect on the process of service provision and the service result gain importance. This is especially true against the background of challenges within the developing demographic changes [14], as on one hand the number of young and well qualified employees will decline while on the other hand the number of retirements will grow in the future. This, in turn, bears dangers especially for knowledge intensive companies because, due to the latter, a lot of knowledge will vanish which cannot be compensated for by the former. Accounting for demographic development in industrialized countries, this paper examines whether innovative team performance is affected by individual demographic variables.

Results of research with regard to this problem statement are inconclusive. *Similarity theory* [15] predicts that homogeneous teams are more productive since group members share mutual attraction. At the same time, heterogeneous groups are supposed to be less productive due to the inherent conflict in those groups. On the contrary, "*equity theory* predicts that team performance is enhanced by the tension that arises between dissimilar individuals within a group" [16, p.311]. Empirical evidence has been reported for both approaches. -These predictions, however, are not independent of the type of task [17].

D Research Hypothesis

Since the literature does not provide conclusive evidence and theoretical approaches allow for argumentations in both ways, the first hypothesis is formulated in a non-directional way:

Hypothesis H 1: There is a difference in outcome productivity between age homogeneous and age heterogeneous teams.

According to the often cited moderating role of task characteristics the two different team types will perform differently on the tasks. Therefore, the second hypothesis is:

Hypothesis H 2: The differences in outcome productivity are contingent upon type of task.

In order to evaluate the hypotheses, a laboratory study was conducted at the Chair and Institute of Industrial Engineering and Ergonomics at RWTH Aachen University.

II. METHODS

The purpose of the presented study was to evaluate whether task characteristics and composition of teams (i.e. age homogeneous vs. heterogeneous composition) have an impact on team outcome.

A Participants

A total of 84 persons (42 female) with a mean age of 43.8 years (SD = 14.1) participated in the study. Participants were recruited from general population by advertisement in either a local newspaper or lectures. Work experience (not applied to students), was the only inclusion criterion. Subjects were organized into groups of four, which resulted in a total of 11 age homogeneous and 10 age heterogeneous groups. Groups were balanced with regard to gender. All participants received monetary reward.

B Tasks

The tasks were designed in such way that they would resemble a problem statement faced by research and development teams.

The first task was to design an innovative concept for a shower. In order to make results comparable, the groups were instructed to take a three step approach with each phase lasting 10 minutes. In the first phase the group brainstormed on which features could be included in an innovative shower with the objective to come up with as many ideas as possible. Following that, the group had to agree on three ideas from the brainstorming which had to be elaborated further. In the final stage a sketch of the concept had to be drawn and a script had to be formulated. The group was instructed to arrange sketch and script in such way that it would persuade a fictitious executive board. This task was meant to resemble phases of idea generation during an innovation process and will be referred to as the brainstorming task.

The second task was to plan and build a tower according to contrary instructions. The instruction was to construct a tower which had a height of at least 80 cm using as few stones as possible. Further, the tower should possess a viewing platform and be suited as a flagship for a construction company. In contrast to the first task, this task was meant to resemble phases of (idea) implementation during an innovation process. This task will be further referred to as the construction task.

C Independent and Dependent Variables

Based on individual age, groups were composed as either homogeneous or heterogeneous teams. Teams with a standard deviation of age below 12.5 years were classified as homogeneous teams whereas teams with a standard deviation of age higher than 12.5 were classified as age heterogeneous teams. All teams consisted of four team members (2 male and 2 female). A total of 21 teams, 11 age homogeneous groups and 10 age heterogeneous groups, participated in the study. Within the age homogeneous groups there were homogeneous young (n = 4) and homogeneous older teams (n = 7).

Innovative group outcome was measured in a quantitative and a qualitative way. Quantitative measures for the brainstorming task include the number of ideas and the number of unique ideas. Since the capacity of the tower could not be measured, the constructed towers were evaluated by dividing the height of the tower by its weight. This way the teams' adherence to the contradictory instruction could be assessed.

To obtain also a more qualitative evaluation of team performance, the final concepts of the innovative showers and pictures of the constructed towers were subjected to expert ratings. Experts from respective domains rated the originality and the customer value of each concept on a seven point Lickert scale.

D Procedure and Material

Upon arrival, participants were welcomed and the teams were placed in the laboratory. The experimenter handed out the instruction for the first task (brainstorming), explained the three step procedure and answered questions regarding the experimental procedure. Upon completion of the brainstorming task, the experimenter collected all relevant material, handed out the instruction for the construction task and answered all remaining questions. A magnetic countdown timer, which was placed visible to all on the white board, indicated the remaining time for each phase. Participants were provided with pens, paper sheets and post-its for the first and second part of the experiment. Before dismissal all subjects were debriefed and thanked for participation.

III. RESULTS

In order for an inferential test to be statistically significant, α was set to 0.05. The mean number of ideas generated during the brainstorming task was $M = 12.5$ ($SD = 5.2$) in age homogeneous groups whereas the number of ideas in age heterogeneous groups was $M = 12.2$ ($SD = 4.0$). Yet, age homogeneous groups produced more unique ideas ($M = 3.3$, $SD = 2.1$) than age heterogeneous groups ($M = 2.1$, $SD = 0.9$). However, there is no statistically significant difference between age homogeneous and age heterogeneous teams with regard to the quantitative measures in the brainstorming task.

Further, the generated concepts were also rated on originality and customer value by domain experts. Considering the qualitative outcome dimension, homogeneous groups were on average rated higher than heterogeneous groups with regard to originality ($M = 3.3$, $SD = 2.1$ vs. $M = 1.6$, $SD = 1.0$) and customer value ($M = 3.2$, $SD = 1.4$ vs. $M = 2.9$, $SD = 1{,}5$). The according t-test revealed that the difference in the originality rating is statistically significant ($t\,(19) = -2{,}346$, $p = .03$, $d = 1.03$). Hence, the results indicate a tendency in favor of age homogeneous groups within the brainstorming task.

TABLE I
MEANS (AND SD) OF DEPENDENT VARIABLES.
* SIGNIFICANT DIFFERENCES AT *P* = .05 LEVEL.

	Age homogeneous groups	Age heterogeneous groups
Number of Ideas	12.5 (5.2)	12.2 (4.0)
Number of uniqe ideas	3.3 (2.1)	2.1 (0.9)
Originality Brainstorming*	3.3 (2.1)	1.6 (1.0)
Customer Value Brainstorming	3.2 (1.4)	2.9 (1.5)
Quotient Height/Weight*	6.3 (2.6)	9.9 (4.8)
Originality Construction	3.8 (1.6)	3.7 (0.9)
Customer Value Construction	4.3 (1.3)	4.5 (0.5)

The second task aimed at the implementation phase of innovation projects. In this type of task again quantitative and qualitative measures were employed. The quotient of tower height and tower weight indicated how well the teams performed with regard to this task, with a higher figure on this measure indicating better performance. The results show that age homogeneous teams achieved an average score of $M = 6.3$ ($SD = 2.6$), while age heterogeneous teams averaged $M = 9.9$ ($SD = 4.8$). The corresponding t-test was statistically significant with $t(19) = 2.194$, $p = .04$, $d = 0.93$.

Next to objective measures, the same criteria as in the brainstorming task pertaining to quality were applied by domain experts, i.e. architects. The mean rating of the originality of the construction did not differ heavily between age homogeneous teams ($M = 3.8$, $SD = 1.6$) and age heterogeneous teams ($M = 3.7$, $SD = 0.9$). The same holds true for the customer value rating ($M = 4.3$, $SD = 1.3$ vs. $M = 4.5$, $SD = 0.5$, respectively). Both differences were not significant on a statistical basis.

IV. DISCUSSION

The aim of the laboratory study was to investigate whether team composition and task characteristics do have an impact on innovative team performance such as complex engineering services. The results indicate that both hypotheses can be confirmed. Hypothesis 1 stated that age homogeneous and age heterogeneous teams differ in outcome productivity. The analysis revealed significant differences between these two types of teams with regard to quantitative and qualitative measures. For the brainstorming task, age homogeneous groups produced statistically significant more original ideas than the age heterogeneous groups. This difference, however, was reversed with the outcomes of the construction task, as predicted by hypothesis 2. Age heterogeneous groups showed better performance than age homogeneous teams with regard to the constraints given in the task instructions.

Applied to the provision of engineering services, the results indicate that team composition and task characteristics need to be accounted for. Age homogeneous teams are to be preferred over age heterogeneous teams when the task mainly involves generation of ideas. Age heterogeneous groups, on the other hand, seem to deal better with tasks demanding the implementation of ideas or concepts. The results are in line with studies indicating that teams with higher diversity benefit when task complexity is also high [17]. As age homogeneous teams and age heterogeneous teams show respectively better performance, the results indicate that demographic development may not pose a major threat to companies for service provision productivity, as both type of teams will be available to organizations. When designing a team for a specific task, the nature of the task should be matched with the proper type of team composition.

The study also faces a number of limitations. First and foremost, the study was placed in a laboratory setting, meaning that there has to be a tradeoff between the innovativeness of the task and the possibility to measure and compare team outcomes. Further, team members only got to know each other during the session while members of real work teams often know each other for a longer period of time. Although the service productivity model [10] explicitly includes the customer's position in service provision, the present study only considers one side of the model since there are no customers available in the chosen setting. Finally, as is the case with all studies which have the group as the unit of analysis, the 84 participants lead to sample size of 21, which is comparatively low. Hence, with regard to statistical power, a larger sample size would be desirable.

V. CONCLUSION

The study provides the foundation for effective team composition within the domain of service provision. It emphasized the importance of task characteristics in team performance. Further, the study provides an empirical validation of the proposed service productivity by showing effects of a factor in the potential dimension on the overall result in the outcome dimension which is moderated by the process dimension.

As mentioned above, weaknesses in the study design need to be addressed. Therefore, a follow up study is already being conceptualized. This follow up study will try to increase sample size and should be placed in the field rather than in the laboratory. Additionally, different tasks, which still adhere to the proposed distinction in idea generation and idea implementation, should be employed. Yet, the task design will face the same tradeoff between innovative design and comparability as in the present study.

Finally, together with findings from a survey, the results of this and the upcoming study will be used for the development of a simulation tool based on Design Structure Matrices [18]. The simulation tool considers relations between task characteristics, skills and abilities and allows comparisons between different team compositions for a given innovation process

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