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Emerging Leadership Roles in Collaborative Engineering Sessions

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Abstract

Purpose To deal with the rising complexity of civil engineering projects, practice starts relying increasingly on collaborative design meetings. Leadership behaviour in such meeting is not yet well understood despite the importance of such understanding to manage collaborative design meetings well. The purpose of this study is to explore emerging leadership behaviour in design meetings through a detailed grounded theory development study into leadership behavior within design teams.

Design / Methodology / Approach We conducted a grounded theory development study using recordings of seven meetings of a collaborative design team within an academic setting. The recordings of the design meetings were transcribed and analysed using conversation analysis methods. Grounded theory was developed through qualitative coding of the transcripts of the meetings' conversations.

Findings We show that the participants in the design meetings utilized four different behavioural approaches to leadership: outcome oriented, administratively oriented, entrepreneurial oriented, and team integration oriented. Our findings also show that each of the participants employed each of the different leadership approaches during the design sessions and that leadership was highly emergent and dynamically changing.

Originality We provide strong evidence for the necessity to consider leadership in collaborative design teams as a highly flexible and emergent phenomena. Our study also shows that the four behavioural approaches to leadership might be good categories to understand these dynamics.

Research Limitations / Implications We only analyzed meetings of one design team within an academic setting which might reduce the possibility to generalize results widely. Future research should try to reproduce the work observing collaborative design meetings in real practice and across different organizational cultures. Still our study points to the requirement to understand leadership in collaborative design teams as a highly dynamic and emerging phenomena.

Practical Implications The four categories of leadership behaviours provide participants within collaborative design efforts a means to understand their own and others behaviour. Our results also provide important clues that managing collaborative design teams well requires establishing different leadership approaches at different times.

1. Introduction

The steadily increasing complexity of modern construction designs demands a high level of expertise in all functional disciplines involved in a construction project [De Weck et al., 2011]. The disciplines vary from the architects, the structural engineers, the electrical and building physicist engineers, the contractors, the quantity surveyors and the material suppliers. To collaborate, the specialists of the disciplines need to coordinate at a high degree.

Despite the rising complexity, in the construction industry, currently, most projects are still centrally coordinated with an instructed planning office responsible for the coordination of the planers of each specialty. In this mode of organization, each of the specialists prepares subsystem designs relatively independently. At the same time, the planning office integrates each of these designs. An advantage of this approach is that the use of human resources is flexible, and the process can be executed as a routine. On the other hand, the process of centralized integration of specialty designs becomes increasing cumbersome with rising design complexity. This leads to problems with delivering high quality designs within a reasonable time. Often, design issues and conflicts are only discovered late in the design phase or even not until the construction phase. Changes in design are often carried out slow, and the opportunity to find interdisciplinary solutions to create the most optimized design is reduced. Construction design on complex projects becomes a long and expensive process [Bandecchi et al., 1999].

Because of these shortcomings, practice slowly starts employing more collaborative forms of engineering "which provide a better performing design method by taking full advantage of modern information technology" [Bandecchi et al., 1999, Anumba and Evbuomwan, 1997]. Collaborative engineering "is a systematic approach to integrated product development that emphasizes customer expectations, and embodies team values of cooperation, trust and sharing. Decision making in collaborative engineering is by consensus, involving all perspective in parallel, from the beginning of the product life-cycle" [Bandecchi et al., 1999].

It is well established that during such collaborative engineering meetings, the cross-functional collaboration of the team must be reinforced by leadership practices [Ng et al., 2010]. However, so far leadership practices as they relate to collaborative engineering teams is not well explored. Some early studies identified the context in which leadership takes place [Hiller et al., 2006], but little is known about the detailed leadership dynamics within collaborative engineering meetings. The few existing studies, discussed the importance of specific roles within meetings, such as the role of the boundary spanners in intercultural teams [Di Marco et al., 2010, Di Marco and Taylor, 2011]. Other studies have shown that leadership within collaborative engineering meetings is a highly dynamic and emerging phenomena [Zerjav et al., 2014, olde Scholtenhuis et al., 2021].

The here presented study had the goal to further shed light on these dynamic and emergent leadership practices. To approach this research interest, we studied seven collaborative engineering sessions using a grounded theory development approach [Strauss and Corbin, 1997]. We recorded the seven sessions, transliterated the recordings, and coded as well as analyzed the transcripts.

Our findings show that all participants in the engineering session occupied leadership positions at different times throughout the engineering effort. Following Adizes [1976] well established leadership roles, We show that participants of the collaborative engineering meetings shifted their approach to leadership from outcome oriented, to administration oriented, to entrepreneurial, and to integrative flexibly at different times within the meetings.

The rest of this paper is structured as follows: The next section, summarizes the recent scientific work in the area of collaborative design and leadership. Afterwards, the paper introduces the details of the followed research approaches. The paper then continues with reporting the findings of the study. Before concluding, the paper finally provides a detailed discussion of the scientific and practical implications that follow from the findings, but also of the limitations of this study together with suggested topics for future research.

2. Collaborative Engineering and Leadership

Following Stephanou and Spiegl [1992]'s definition, collaborative engineering means to include all technical and functional considerations of all disciplines from the beginning of the design phase until the manufacturing so that solutions to potential problems are developed as early as possible, and the design is continuously optimized. Collaborative engineering entails that all specialists work on the design simultaneously from the beginning of the project. To succeed with collaborative engineering, the following key elements are required: a well organized process, a multidisciplinary team, an integrated design model, and a dedicated facility and software infrastructure [Bandecchi et al., 1999].

Of course, collaborative engineering needs to be organized so that each team member can spend enough time to work independently on their highly complex mono-disciplinary engineering task. However, the value of collaborative engineering is mainly created in meetings during which the "integration of value and design, builders and operator's knowledge and sustainable design principles, materials and technologies" occurs [Fischer et al., 2014]. In these meetings, the team members can "decide, coordinate, [and] work [...] effectively" [Fischer et al., 2014] leveraging integrated information that is created at once and used by all.

Collaborative engineering meetings allow each participant to understand the interdependence between different disciplinary sub-systems, each having a possible impact on the other subsystems. Moreover, the meetings allow to propagate changes through the entire system cross cutting disciplinary boundaries. It is well established that capable cross-functional teams work in an encouraging supervisory and directorial atmosphere [Abdalla, 1999]. To establish, such an atmosphere, the cross-functional collaboration of the team must be reinforced by leadership practices to create a highly motivated, multidisciplinary team that productively engineers [Bandecchi et al., 1999, Ng et al., 2010]. A sound leadership structure is therefore one of the most important managerial aspects to enable efficient collaborative engineering work.

It is surprising that despite the importance of leadership within collaborative engineering meetings, research into the topic of leadership in collaborative design meetings seems still be underrepresented in the engineering, architectural, and construction management

literature. Most leadership studies mainly explored leadership as it relates to aspects of managing firms and construction projects. These studies by large follow a behavioral approach aimed at identifying a set of personality traits, such as appearance, intelligence, self-reliance and persuasiveness.

Notable examples among this large body of work are, for example, Zaman [2020]'s survey study on transformational leadership, a practice that focuses on leading towards continuous improvement, to manage mega construction projects. Other survey based studies have shown how leadership as a general concept is an important management competency which is highly correlated to overall project performance [Khattak and Mustafa, 2019], project sustainability [Meng et al., 2015], or project safety [Lingard et al., 2019]. Finally, a large body of survey based studies exist that identifies prevailing leadership styles among a population of construction professionals, such as [Randeree and Chaudhry, 2012] recent study into leadership styles in the United Arab Emirates.

While these studies have provided well versed strategic insights, it is well established in the general management literature that the qualities of a person seldom lead to successful leadership behavior at the operational level, in particular, within meetings [Çirkalar and Duygulu, 2009]. Therefore, studies that follow a behavioral approach, which suggests that effective leaders influence the team members through their behavior might yield important additional insights specifically targeted towards managing collaborative design meetings. The recent qualitative studies of Abdirad and Dossick [2019] into the change of the Architectural practice in collaborative engineering projects or Ibrahim et al. [2018]'s detailed study into team integration practices further point towards the utility of in depth studies that explore the behavior of architectural, engineering, and construction practitioners.

In the general management field, in depth studies into specific leadership behavior, has been informed mainly by contingency theory [Çirkalar and Duygulu, 2009]. These contingency based studies assume that appropriate leadership behavior varies in different situations. Fielder [1967] assumes that whether a group is capable or not depends on a proper match between the leadership behavior and the degree to which the situation gives control and influence to the leader. Situational factors may include the leader's authority, the relationship between the leader and the team members, the type and nature of work, which should be in harmony with the leadership behavior. The basis of the situational approach is the dynamic interplay of the three factors: the leader, the team and the situation in which they all take part [Kangis and Lee-Kelley, 2000]. Contingency influenced theories cannot serve as a general theories of leadership [Çirkalar and Duygulu, 2009]. Rather these theories suggest that different leadership behaviors are most effective in diverse situations [Hersey and Blanchard, 1969] and no single behavior is suitable for all situations. Therefore, an effective management team should consist of not only one but several roles [Müller and Turner, 2007] .

In a comprehensive review of leadership models with relation to the Architectural, Engineering, and Construction management field, Larsson et al. [2015] assessed contingency based theories about different roles of leadership behavior. They found that the four within the management literature widely agreed upon roles of Producer, Administrator, Entrepreneur/Developer, and Integrator [Adizes, 1976, House, 1971, Grendstad and

Strand, 1999] are applicable in Architectural, Engineering and Construction management. Table 1 summarizes these roles.

While contingency theories of leadership are applicable for relatively stable teams, we assume that with the increasing complexity and demand for flexibility that is required for collaborative engineering teams an even more dynamic leadership model is required. This matches well with modern general management theory that views leadership holistically as concerted action [Gronn, 2002]. With such "collective leadership", the leadership roles are transferred flexibly among the team members. They lead themselves by the interaction among each other and share leadership responsibilities. Collective leadership is important as no single person can occupy all leadership roles that would be required to empower a collaborative engineering team to deal with contingent situations.

To understand leadership approaches, the different roles help to shift focus from characteristics of one person to the relational process of the entire team [Hiller et al., 2006]. Very few studies have explored the phenomena of collective leadership within collaborative engineering team. Notable exceptions are work by Zerjav et al. [2014], olde Scholtenhuis et al. [2021] who found and reported evidence for collective leadership by closely analysing engineering meetings. However, these study could not yet provide evidence for how collective leadership emerges in relation to different leadership roles. Because of this gap, we conducted an exploratory research study that we report in this paper. The next section describes our study's grounded research approach.

3. Research Method

To explore how different leadership roles emerge in meetings we chose a grounded theory development approach. To this end, we started the study with no specific theories or hypotheses in mind, but with directly engaging with data collected from a serious of design meetings. Our objective was to observe and document emerging leadership in collaborative design sessions and to use the gathered material to formalize theories based on these observations. In the following, we describe the analyzed design sessions, how we gathered data, and how we analyzed the data to build grounded theoretical constructs.

Because it was hard to get access to collaborative design meetings in true practical settings - collaborative engineering projects are still very scarce - we decided to observe the collaborative design work within a project based academic course of a European university. Despite the academic nature of the design project, the project assignment for the course centered around a real project with the aim to design a multi-functional building hosting some important training and public relation functions for a large international high-tech company. The project was provided by a large international design and engineering consultancy and can be considered as a highly realistic assignment. During the course, the students needed to meet once a week for at least 1,5 hours for collaborative project meetings within a specific room, that was equipped with software tools, computers, smart boards, and other devices to support collaborative design work. The students following the course were randomly assigned to design teams. The participants of each team had to choose an engineering specialism matching with their respective professional or academic background.

TABLE 1
The four behavioral leadership roles according to Adizes [1976]

Role	Description
Producer	Producers are highly motivated and energetic leaders and work long hours. They show little emotion and are not concerned about ensuring peoples well-being. Producers like to attain tangible results quickly and like to delegate to team members, making them achievement-oriented. They dislike unclear details, ambiguous situations and abstract considerations [Larsson et al., 2015]. They feel that teamwork is less efficient due to communication needs [Ten Have et al., 2003].
Administrator	Contrary to the Producers, Administrators are quiet and cautious leaders, always in need of understanding processes and situations entirely before acting. They dislike unplanned activities preferring routines, that bring structure, stability and order to a situation. Because of this, the Administrators make decisions slowly and carefully. Also, the Administrators are highly concerned about what other people should do and how they should do it [Larsson et al., 2015]. In the opinion of Administrators, teams can only function if they follow team roles [Ten Have et al., 2003].
Entrepreneur	Entrepreneurs are quickly bored by routine activities and work irregular hours. Sometimes they might not even show up at all. They are not interested in short term results but are stimulated by novel challenges, exciting opportunities and changes. Therefore, they inspire others, are action-oriented and focus on more considerable future potential achievements. They like to be the centre of attention [Larsson et al., 2015]. Teams are an audience for the Entrepreneurs [Ten Have et al., 2003].
Integrator	Integrators are team builders. They focus on managing interpersonal relationships. They want to see the team as a collective, where the organisation can only function with all pieces included. Integrators try to align everybody's concerns and interests and are less occupied with formal roles and titles. They try to fuse the team into a combined and unified source [Larsson et al., 2015] and see the teamwork as a goal in itself [Ten Have et al., 2003].

TABLE 2
Notations used during the transcription of the recordings

Notation	Meaning
<inaudible>	Inaudible material that was not included in the analysis
<all talking in a muddle>	same outcome as inaudible
==	end of an incomplete sentence that will be continued later on
==–	incomplete sentence that will not be completed later on
...	speaker pauses
<German>	speaker uses the German language
<translated from German>	the researcher translated a German part of the conversation into English

For this study we chose to observe the work of one of these design teams. The disciplines chosen by the students of this design team consisted of an architect, a structural engineer, a building physicist and an energy physicist. With the consent of the attendees, the meetings were recorded during the sessions, but the work of the students outside the meetings were not tracked.

We transcribed all recordings using the notations listed in Table 2 . While transcribing we attempted to capture the conversations of the students as closely as possible. To this end, we included expressions, such as, "ehm" and sentences spoken several times consecutively, such as, "You mean this...", "you mean that...", "uhm, you meant that". Also, the speakers were not edited for English grammar or clarity. The team members were of various nationalities, and none were native English speakers.

For the analysis, the transcribed conversations were segmented in small dialogue units called statements. A statement is identified with the beginning of a dialogue turn of one person to the change of the dialogue partner. Such "speaker turn structures" each represents the extent to which persons convey their idea uninterrupted or until the point of interruption. In the final transcripts, the entire conversation of the meetings were organized as follows: [Attendee] [:] [Starting time of statement] [content of statement] [optional: notation] [paragraph]. In a next data preparation step, statements that were classified as valuable for the research cause, were further segmented at utterance level. Utterances are small dialogue units within a statement. Subdividing statements into utterances allows for a more detailed analysis of specific dialogues than speaker turns. Finally, all statements were designated an attendee code indicating the person who spoke.

After transcription we followed the grounded qualitative data analysis approach suggested by [Strauss, 1987]. In a first step of data analysis, we openly coded the transcripts at utterance level. During this step, we developed an initial set of codes describing behavior of the participants in the meetings, without much interpretation. By conceptually coding the meaning of each utterances in this way, we were able to develop first theories and possible interpretation angles. Following the qualitative data analysis approach, we then iteratively simplified the open codes, discarded irrelevant codes and merged similar codes. This helped us to group the behavioral codes from the open coding stage into higher level concepts and to establish first relationships between these concepts. In a final

TABLE 3
Final coding scheme for leadership categories that emerged during the grounded research effort (P - Producer; A - Administrator; E - Entrepreneur; I - Integrator)

Leadership Behaviour	P	A	E	I
Checking presence / participation of team members	X	X		X
Classification of importance/ need	X		X	
Classification of objectives		X	X	
Commanding a member to conduct a task	X		X	
Coordinating design tasks		X		X
Coordinating working time / schedules		X		X
Encouraging an expert		X		X
Making a final decision	X	X		
Focusing the group towards a design process	X		X	
Focusing the group towards a design objective		X	X	
Focusing the group towards a design challenge		X	X	
Raising a concern with respect to a knowledge gap		X		X
Showing interest in the work of others		X		X
Opening a previously made decision			X	X
Praising a team member				X
Proposing a follow up action		X	X	X
Teaching / Providing support		X	X	X
Trying to include a team member into a discussion		X		X

stage of analysis, we tried to generate theories by asking specific questions, comparing codes, writing a number of memos and creating diagrams. In particular, we were looking for specific action-reaction patterns in the data which helped us to understand the leadership behavior in the meetings better.

In this phase we also started to match our emerging findings with the leadership category and realized that the leadership roles by Adizes [1976] provided a good framework to understand the different behaviors within the meeting. This finally led us to a final iteration of the coding effort during which we coded all statements that pointed to participants engaging in any of the four leadership roles with a specific coding approach as summarized in Table 4. Typical examples of utterances that we coded as leadership behavior can be found in Table 3. Overall, we coded 1306 utterances across the transcripts of the different meetings.

An interesting pattern of dynamic changes within the leadership styles, roles, and persons emerged that we describe in detail in the next section.

4. Emerging Leadership Roles

A summary of the final leadership behaviour codes are presented in Table 5. This summary provides a good overview of the diversity and changing nature of leadership roles.

TABLE 4
Typical examples of observed conversation to identify leadership behavior

Leadership Category Code	Example (D=Document, Number of Document, Time of utterance)
Checking presence / participation of team members	D, 13, EP, 2:00: [a student] is not coming today, is he?? <translated from German.
Command and expert to work / act	D, 10, A, 43:59: just start testing! D, 10, SE, 1:00:57: I think I was asking to you <inaudible> your results?
Coordinating design tasks	Does she need here when the window does she need the exact window type? Or she just does she only need, the, the height and the ling and the ==- D, 10, SE, 10:28: <inaudible> solar panel which affect the architectural design because we talked to that maybe we should maybe use a green rooftop
Coordinating working time / schedules	D,10,A,29:06: alright, but wouldn't that mean that you all have to wait for me now to get, that I get my work done
Final decision about issue	D,16,A,25:49: okay what we have to do that one time is D,17,A,9:38: so I'll definitely, we have to go with 24
Focusing the group towards a design challenge	D,10,BP,1:01:36: So first of all, you have to locate your construction you have to ... which location do you want
Praising a team member	D,16,SE,1:03:18: that's nice

During the meetings 36% of the leadership behavior was of an administrative nature, 29% of an integrative nature, 24% of an entrepreneurial nature, and only 11% of the observed leadership style followed the producer role. Looking at the different roles within the meeting, the Architect was the participant that was moving into a leadership role most often (694 times). At the same time, all other participants of the meeting also moved into leadership roles with the Building Energy Consultant moving in leadership positions 234 times, the Electrical Consultant 266 times, and the Structural Engineer 112 times.

What is also apparent from Table 5 is that each of the four participants engaged in leadership behavior. While the Architect enacted leadership behaviour most often (694 occurrences), the Building Energy Consultant and the Electrical Consultant also moved into leadership roles in a significant number of occasions (BC: 234 occurrences; EC: 266 occurrences). Even the Structural Engineer enacted leadership behavior in 112 occasions.

TABLE 5
Number of coded statements according to leadership style, grouped by team members (A - Architect, BC - Building Energy Consultant, EC - Electrical Consultant, SE - Structural Engineer

Leadership Role	A	BC	EC	SE	Sum	Percentage
Producer	76	22	40	13	151	11%
Administrator	272	70	86	38	466	36%
Entrepreneur	130	73	78	26	307	24%
Integrator	216	69	62	35	382	29%
Sum	694	234	266	112	1306	100%

Looking at the leadership roles per participant more closely, a clear pattern of a preferred role is apparent for the Architect. According to our observations, the Architect preferred the role of an Administrator, moving into this role 272 times, followed by the role of an Integrator (216 times), the role of an Entrepreneur (130 times), and the role of a Producer (76 times). The three Technical Experts within the meeting seemed to prefer the roles of Administrator (BC: 70; EC: 86; SE: 38), Entrepreneur (BC:73; EC: 78; SE: 26), and Integrator (BC: 69; EC 62; SE: 35) rather equally. The role least preferred by all participants was the role of the Producer.

5. Discussion

The findings of our study show that leadership behavior clearly emerged within the observed collaborative design team. Our data shows that all participants of the meetings took on leadership roles. Moreover, judging from the amount of occurrences, leadership behavior came natural to the participants, even though none of them can be considered as experienced design professionals. Our results also show that participants of the design meetings enacted all four leadership roles. While certain roles were more dominant, none of the roles were underrepresented.

The results of our study lead to a number of important implications for research and practice. For leadership research our results provide strong evidence that leadership behaviour in collaborative design meetings cannot easily be inferred from personal characteristics of the meeting participants. Our data clearly shows that leadership roles varied in the course of the project, but also that each member of the project team enacted each of the different leadership roles, independent from their personal characteristics. Our data shows that during the collaborative meetings, leadership behaviour and roles can only be identified from the respective actions of the team members. These actions by nature were influenced by the changing position of the individuals while contributing to the developing design and by the interaction within the team. For example, the Architect, came into focus at the beginning of the design effort. Later on, however, the Structural Engineer exhibited more leadership behavior as important structural design questions had to be solved.

The results of our research also show that the leadership roles of Adizes [1976] provide appropriate categories for understanding leadership behavior within collaborative design teams. We believe that future research can leverage the categorization scheme and the overall qualitative research approach. Studies should reproduce or challenge the leadership behavior we found during the design meetings we analysed. More evidence is required for our initial findings also with respect to the many contextual factors that might have influenced our results. For example, the team members of this study were largely German and different leadership behavior might be observed in more hierarchically organized cultures. It would also be important to reproduce our study in professional collaborative design settings with participants of significant more design experience than our students, that at the same time might also exhibit political behavior or might be used to traditional non-collaborative design efforts.

Next to reproductive studies, the research approach provided here could also be used to design studies to understand the effect of leadership and leadership behavior on team performance. Our study for example cannot provide any insights into the extent and type of leadership that is required within collaborative design meetings that lead to outcomes, such as high productivity or creativity. Building upon our work, future studies could provide important clues of how to set-up and manage high performance teams. Such studies could also provide important findings with respect to understanding how individuals influence team performance that could be used to train design professionals. Finally, studies could be conducted that shed more light on the mechanisms behind the emergence of leadership roles. While we show here that leadership roles emerge, we do not provide much insights on necessary conditions that are required for certain leadership behaviour to emerge. Again such research could provide important implications for managing collaborative design teams.

Next to developing a better theoretical understanding of team dynamical processes and their influence on meeting efficacy, more practice oriented research is also required. Assuming that collective leadership is the right choice for participatory design meetings, the question, for example, arises how different leadership roles are allocated. If designers intend to employ a collective leadership for their project from the beginning, it would be of interest to find an optimal distribution for the leadership roles depending on the project requirements and the team characteristics. At the same time, research into strategic role allocation at the beginning of a design effort should also be approached carefully. In the project we observed, for example, that no allocation took place in the beginning, and we assume that this would have been detrimental to success. After all, at the beginning of the project the participants did not know each other well enough to a priori allocate roles to each other. Practice oriented research on possibilities to allocate leadership roles strategically needs to be always complemented with more critical research that explores the relation between emergent leadership and team efficacy.

Of course our study is not free of limitations. While our grounded and qualitative research approach allowed us to gain deep insights into the dynamic of the team, our personal experiences and personality influence the research process. As a result, our individual reactions and perceptions in the process of data collection initially had a direct influence on the course of the project study and finally in the evaluation and the inter-

pretation of the collected data. Moreover, while our grounded theory development was structured using well accepted grounded theory development approaches provided the researcher with a procedural structure, our approach was highly iterative. This introduced a high level of path dependency within the research process. Other researchers might have found other results or followed up on other theories.

Nevertheless, despite the above limitations the results of the study provide important practical implications for managing collaborative design efforts. Most importantly maybe is to realize that despite the lack of formal hierarchy leadership roles will emerge. Spinning this idea further there is no strict requirement to clearly define and set-up formal leadership structures for collaborative teams to work. Of course, an initial set-up of hierarchical structures might be required to achieve satisfactory team performance, but at the same time, establishing such a hierarchy a-priori might be reducing team performance and creativity as it will inhibit required leadership behavior to emerge according to the design task and the team situation at hand.

Additionally, the results of our study can also be helpful for individual designers to better understand the dynamics of the collaborative design teams they are working on. The here defined leadership roles might provide cognitive patterns that help designers to understand how and why they themselves, but also different team members influence a meeting and their team members. The roles might also help designers to draft appropriate strategies to engage within collaborative design teams. Finally, the roles and the insights provided by our study can be used to teach collaborative design courses to engineering students.

6. Conclusion

We reported on the results of an exploratory grounded research study into leadership behaviour during collaborative design meetings. The results of the study show that leadership behavior within a series of seven design meetings of a collaborative design team emerged naturally. The results also show that participants within the meetings used four different leadership approaches, from outcome oriented, to administratively oriented, to entrepreneurially oriented, to integration oriented. We also show that each of the participants of the design team employed each of the different approaches throughout the seven meetings. In the end, our findings provide strong evidence for the existence, but also for the requirement of highly emerging and dynamic leadership behaviour during collaborative design efforts.

While the generality of the findings are limited to this one design team within an academic setting, the results might still have important implications for engineering management research and practice. For one, the four categories of leadership practice represent a good lens for scientific studies within leadership behavior. At the same time, the categories might provide a helpful lens for practitioners to understand the dynamics within their collaborative design team. Finally, the understanding that leadership is highly dynamic and only to a certain extent a personal characteristic might provide a fresh approach to managing engineering design efforts in an effort to increase possibility for collaboration and integration - two ingredients that are by now widely accepted precursors for the

successful engineering of complex construction projects.

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