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Key success factors of collaborative planning processes

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Building design and planning is a typical instance of coordination and collaboration processes, where experts work together in fulfilling their own distinct planning tasks that build the basis for the realization of the joint building project. Increasing requirements on building performance, like resources and energy efficiency, resulting in growing project complexity call for a holistic view of the project rather than a fragmented one, as strengths in one domain cannot easily offset weaknesses in others. Traditional sequential planning processes fall short in fulfilling this requirement. This study compares sequential and integrated building design in a large laboratory experiment with student participants. The focus of the study was to examine the impact of personality traits on team performance in different planning procedures in a building planning experiment. We identified that the success of design processes relies on both skills and the personality traits of the team members. In the integrated planning treatment groups with higher level of conscientiousness achieve worse results, whereas groups with higher level of conflict and workload achieve better results. We conclude that, when choosing or designing the optimal planning procedure for a team, personality traits should be taken into account since they significantly influence results.

Keywords: Experiment, integrated building design, integrated planning, personality traits, sequential planning.

Introduction

Integrated building design is based on collaborative planning and has been recommended as the method for the realization of a sustainable built environment (Rohracher, 2001; Alshuwaikhat and Abubakar, 2008; IWHBD, 2008; Heiselberg *et al.*, 2009; Russell-Smith *et al.*, 2014). The fragmented nature of the architecture, engineering and construction (AEC) industry is still the greatest obstacle for the achievement of better building performance in terms of energy- and resource efficiency, for which increased integration and coordination of the different disciplines involved in design and construction process are necessary (Faniran *et al.*, 2001). The principles of integrated building design originate in concurrent engineering (CE), which was first introduced in the automotive and aeronautical industry. CE is based on principles such as the use of cross-functional multidisciplinary teams, the use of software tools and digital models, sharing of information, communication and coordination (Anumba *et al.*, 2002). However, several authors criticize the direct transfer of the CE methods from the manufacturing industries to the AEC industry—a customized process is needed to meet the specific requirements of the construction industry (Faniran *et al.*, 2001). Khalfan *et al.* (2001) argue that the lack of realization of the full potentials of CE—concerning cost and time reduction and increases of effectiveness and efficiency—might originate in the insufficient planning and implementation of CE. Therefore, deeper knowledge of the actual design of the integrated design process is crucial. In recent years especially integrated project delivery (Prins and Owen, 2010; Lahdenperä, 2012), collaborative planning in the AEC industry (Sturts Dossick and Neff, 2011; Dewulf and Kadefors, 2012) and project-organizations engaged in collaborative practice (Love *et al.*, 2010; Hartmann and Bresnen, 2011) are upcoming topics in the context of CE that have increasingly been discussed in literature.

The identified advantages of CE originate in the integration of the concept–design–production phases

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and overlapping of activities, resulting in a reduction of changes, rework and consequently of the number of possible errors. Constraints and conflicts can be detected in the early design stages, where alterations can be carried out at low cost, the number of design alternatives is multiplied through early collaboration of all constituents and requirements of suppliers and users can be better grasped by early collaboration to improve the overall product quality (Wang *et al.*, 2002). The importance of early phases, like conceptual design, plays a crucial role for future product performance: Design decisions account for 75% of product cost (Hsu and Liu, 2000). The research community has generally advocated CE as a successful method for improvement of lead time, cost reduction and product quality (Pennell and Winner, 1989; Smith and Eppinger, 1998).

Concerning the transferability of insights from CE to the AEC industry, attention has to be paid to specific characteristics of this industry. CE is basically developed for the introduction of serial products, whereas building design and related design and construction remain the domain of prototyping, because of unique characteristics such as the building site, building orientation, varying needs of users and investors, varying planning teams and rare in-house planning.

CE in industry and integrated planning in architecture and construction differ through project organization: In industrial design the whole team (designers, builders and testers) are known from the beginning and are mostly in the same company—this is not the case in the Central European AEC industry. One team carries out the project development and feasibility study;another (competition winning) team carries out the actual design; the contractor is known after the bidding process, where design is already done. The architecture and construction projects are multi-party projects, where there is no unity of ownership, command and culture, which is the case with in-house industrial design (van Aken, 2003).

These differences of the industries lead to specialities in integrated planning that make it distinct from standard CE and call for additional research. AEC practice reports the need for the change of the traditional design process, which is arranged in a sequential manner, with little communication between constituents of different phases: 'There seems to be thinking out there that there's got to be a better way to do this than the way we've been doing it?' (AIA, 2009, p. 5). The practitioners report the lack of early collaboration as especially deficient; as such the needs of users can hardly be considered; moreover, the lack of knowledge transfer from planning to the operational phase is problematic (Kovacic and Müller, 2011).

Despite this development the success factors of the different planning processes are yet not well understood. We lack solid empirical foundations to judge if and under which conditions integrated planning is superior to sequential planning. The research question of this paper therefore is: What are the key success factors of collaborative planning processes. In an attempt to take the first steps towards answering this research question, we conducted an explorative laboratory experiment with undergraduate participants. We collected data about possible success factors and analysed their effects on team performance through a regression analysis.

The remainder of this paper is structured as follows: After this brief motivation the second section discusses potential success factors for collaborative planning and formulates hypotheses for our study. The third section describes the experimental study and the data gathered. Results of regression analyses of the collected data are presented in the fourth section. The fifth section summarizes the main results and draws conclusions for research and practice.

Success factors in collaborative planning

The following section deals with potential success factors of collaborative planning, which we subsequently evaluate and analyse in the experimental setting. Literature discusses several factors potentially influencing the performance of a team:

(i) the team potential and the effort they spend on the planning task, (ii) the attitudes towards working in a group, (iii) the planning procedure used during collaborative planning and (iv) personality traits of the group members. We subsequently discuss these factors in detail and formulate hypotheses concerning their assumed influence on team performance. The regression analysis in the fourth section also covers the interaction between these effects, as it can be assumed that the effect of the usage of different planning procedures—i.e. of integrated and sequential planning—is dependent on attitudes towards working in groups and personality traits of the team.

Qualification and effort

As in any task, also in collaborative design, the qualification of the participants is based on education and experience. However, it not only matters whether the group possesses these qualifications, but also to which extent the group uses them in the planning process. We therefore formulate the following hypotheses:

H1a: Higher team qualification positively influences the team performance.

H1b: Higher team effort positively influences the team performance.

These two aspects are relevant in individual as well as in group tasks; however, group tasks additionally feature the problem of collaborating in a team which is not relevant in individual tasks.

Group work

Jassawalla and Sashittal (1998) claim that participants' cooperation, openness and willingness to cooperate as well as trust are fundaments of high-level integration in teams, which could be endangered by personal attitude such as disinterest towards the collaborative process. Productive joint work in groups covers several relevant aspects, including the team members' general attitudes towards working in groups, how proficient they are in communicating with others and coordinating joint activities. We therefore formulate the following hypotheses:

H2a: Better attitudes towards team work positively influence the team performance.
H2b: Better cooperation skills positively influence the team performance.
H2c: Better communication skills positively influence the team performance.

Besides these attitudes and capabilities of working in groups the planning procedure applied to do so is argued to influence the team performance.

Planning procedure

Building design and planning are typical instances of coordination processes. Hereby, numerous experts (architect, structural and HVAC engineers, project manager, facility manager)—usually associated with different and legally independent firms—work together in fulfilling their own distinct planning tasks that together build the basis for the realization of the joint building project. Their tasks are highly specialized and at the same time highly interdependent. The success of a building design relies on optimized overall results, so that weaknesses in one area cannot be offset by strengths in others. This is even more true for the augmented requirements on building performance and increased complexity of the planning process posed by sustainability and energy efficiency (Nofera and Korkmaz, 2010).

In this newly evolving design field, the traditional planning process that follows a sequential workflow, where each expert performs her/his task on the basis of the previous expert's output, falls short of fulfilling sustainability goals in complex situations. The reciprocal interdependencies between tasks call for an integrated rather than sequential planning process (Thompson, 1967). We therefore formulate the following hypothesis:

H3: The integrated planning procedure will positively influence the team performance compared to the sequential planning procedure.

Personality traits

Collaboration with other team members and team performance to a large extent depends on the personality traits of the team members. This was found, for example, in the field of product development by Kichuk and Wiesner (1997). Personality traits are enduring characteristics of individuals, which cannot be changed easily. An established system for classifying and evaluating personality traits includes the, so-called, 'Big Five': extraversion, agreeableness, conscientiousness, openness to experience and neuroticism (e.g. Costa and McCrae, 1992). Although, to the knowledge of the authors, no studies yet have analysed the effect of personality traits on team performance in building planning tasks, existing literature on team performance in other domains suggests that personality traits of the team influence outcomes (Driskell *et al.*, 1987). Kichuk and Wiesner (1997), for example, found that successful product development teams are characterized by higher extraversion and higher agreeableness, while showing a lower level of neuroticism. The effects of personality traits on team performance, found in existing empirical studies, differ considerably with group size, group task or the domain of the study. Subsequently, we briefly describe the above-mentioned personality traits and formulate hypotheses concerning their influence on team performance in accordance with the majority of the existing literature (Driskell *et al.*, 1987; Kichuk and Wiesner, 1997).

Extraversion paraphrases traits such as sociability, activeness, assertiveness, etc. A high level of extraversion within a team should lead to results that integrate the perspectives and ideas of all involved; we therefore assume a positive relationship between extraversion and team performance, which was also found in the majority of existing studies.

H4a: A higher level of extraversion in the team positively influences the team performance.

Agreeableness includes traits such as courteousness, trust, cooperativeness, tolerance, etc. Empirical studies show mixed results concerning this personality trait. Highly agreeable work groups clearly might improve the working climate and the possibility to overcome conflicts; besides, they could also lead to compromises or the avoidance of productive conflict and the collaborative search for integrative solutions. In general, we assume that the positive effects of high agreeableness in a team surmount its disadvantages and formulate; hence the following hypothesis:

H4b: A higher level of agreeableness in the team positively influences the team performance.

Conscientiousness describes persons who are dependable, careful, thorough, organized, hard-working and achievement-oriented. These qualities can be assumed to be beneficial for team performance in general. However, the increased productivity of conscientious teams might lead to lower creativity in creative tasks like building design. We nevertheless formulate our hypothesis in accordance with the majority of the results of empirical studies which find a positive relationship.

H4c: A higher level of conscientiousness in the team positively influences the team performance.

Traits connected to openness to experience include imagination, curiosity, originality, broad-mindedness, intelligence, etc. Previous studies came to no conclusive results concerning the effects of openness to experience. Its positive effects on the innovative potential of groups could be outperformed by lower efficiency; we argue that for the creative task of building planning openness to experience can be seen as a desirable characteristic of a planning team.

H4d: A higher level of openness in the team to experience positively influences the team performance.

Neuroticism may be perceived as an emotional instability and describes traits like anxiety, depression, anger, emotionality or insecurity. One could hypothesize that neuroticism negatively affects team performance as it might hinder effective collaboration in teams and fuel conflicts. However, in our study we had to exclude this factor of the 'Big Five' due to data collection problems. Pre-tests of the pre-experiment questionnaire indicated that participants were reluctant to answer the questions that measure the neuroticism scale, which could harm truthful information revelation or participation in the experiment.

Method and data

After the discussion of potential success factors and the derivation of hypotheses regarding how they influence the performance of teams, this section will describe the experiment and the questionnaires used to gather the necessary data for our analyses.

Experiment

To investigate the key success factors of collaborative planning procedures, we conducted a laboratory experiment with undergraduate participants from the curricula civil engineering and architecture at the Vienna University of Technology in Fall 2011. The experimental study was part of the research project 'Costs and benefits of integrated planning'.

Previous research on work groups suggests that the type of the task, the size of the work group, the project length and available resources as well as the environment influence the group performance (Cummings, 2004). To gain reliable insights into the effect of the planning procedure—i.e. integrated versus sequential planning—and the effects of personality traits, it is necessary to control for these aspects which is possible in laboratory experiments.

All planning groups consisted of four members, representing roles in the design process (client, architect, engineer, business consultant) with distinct tasks and deliverables. The group task was identical for all groups: the design of a temporary, self-sustained smoothie bar in the surroundings of the Vienna University of Technology main building, the target customer group being students, to ensure that the work groups have sufficient and equal knowledge of the location and the target group. Deliverables for each role included an architectural design drawings and cost calculation for the architect, structural design drawings and calculation as well as the energy-system design drawings and calculation of solar gains for the engineer, cost and benefit calculations for the business expert, and marketing strategy description for the client. The resources were identical (standardized sheets for the drawings, calculation tables and forms, catalogues with equipment) and also the project time was fixed with eight hours (the experiment was scheduled for one whole day).

To ensure equal capabilities in both treatments, information about the participants' professional experience, the progress in their study, drawing skills, etc. were collected—together with other information as described in the subsequent section—by a pre-experiment online questionnaire. Based on this information, pairs of participants with experience as equal as possible were identified and randomly assigned to one of the two experimental treatments (sequential planning or integral planning). Afterwards, within the two treatments, groups of students were created, assigning an architecture student to the architect role of one group at random and three civil engineering students to the remaining three roles (client, engineer and business consultant) at random.

On the experiment day, the participants were split up according to the treatment they were assigned to, and accordingly briefed by the experimenters. Afterwards, the groups (in the integrated planning procedure) or the participants with equal roles (in the sequential planning procedure) congregated in their rooms and started to work on their tasks to perform their deliverables.

The only difference between the work groups was the planning procedure they had to use, which constituted the two treatments of the laboratory experiment. In the integrated planning treatment all four group members sit and work together during the whole experiment—from the initial design until the handing in of the results—discussing and deciding jointly on design solutions. One the other hand, in the sequential planning treatment the different disciplines were situated in different rooms and only allowed to meet in a one-on-one fashion. Communication was restricted to face-to-face meetings and discussions, so that the experimenters who supervised the participants in the different rooms could ensure that the experimental conditions were not violated. The experimental condition was induced by separate briefings of the two sets of work groups, so they did not know about the distinct planning procedures until a debriefing event, where also first results were presented to interested participants.

These two predetermined procedures are argued to best represent the essentials of sequential and integrated planning, respectively. One-on-one meetings require redo-loops in case of additional information, feedback or problems from other professions concerning an accomplished task, as it is the case in sequential planning. If the work group members interact during the whole process, this information can be provided or requested timely and redo-loops can be avoided and joint decision–making will be supported.

The standardization of all available resources, such as the available planning time, materials and human resources, shifts the attention towards the outcomes of the building design process, which was a jury evaluation of the results of the work groups in this study. This is in contrast to the main part of the literature as mentioned in the introduction, which, especially in the domain of CE, focuses on process efficienciessuch as reductions in planning costs through reduction in number of changes or in planning time.

Questionnaires

For the analyses of key success factors, we gathered significant amounts of information on the participants, the planning process of the work groups and their outcomes. The pre-questionnaire elicited demographic data about the participants (age and gender), which we used as control variables in the analyses, as well as information about their experience: full-time equivalent of relevant professional experience, how many semesters they have studied and a self-evaluation of their drawing skills on a four-point scale (from one being very bad to four being very good). Furthermore, the pre-experiment questionnaire surveyed personality traits of the participants including the four relevant traits of the Big Five: extraversion, agreeableness, conscientiousness and openness to new experiences (Costa and McCrae, 1992).

Extraversion (PEI), agreeableness (PAG), conscientiousness (PCO) and openness to experience (POE) were surveyed by standard 10-item scales. Attitudes towards working in groups were elicited from the participants' attitudes towards team work (STW, 9-item scale), attitudes towards cooperation (SCO, 10-item scale) and attitudes towards communication (SCO, 6-item scale). The participants had to answer these questions on a 5-point Likert scale ranging from 1 (by no means at all) to 5 (totally true). Based on the answers of the participants the scales where checked for consistency and reached satisfactory Cronbach's alphas.

During the experiment, the participants continuously self-documented the tasks they were performing as well as the perceived level of workload and conflict within the group (each on a 10-point scale, at least every 30 minutes). The experimenters took care that this information was indicated and reminded the participants if necessary. After the experiment the participants had to fill in a brief post-experiment questionnaire indicating their satisfaction with (i) the procedure, (ii) their result, (iii) the functionality of the team and (iv) the collaboration in the team. Furthermore, they could communicate suggestions or problems. All deliverables were handed over to a jury of five experts from the industry and the academy. The jury members individually evaluated all 40 groups (without knowledge of group participants or planning treatment) concerning four specific criteria (architectural design, structural design, energy efficiency, life-cycle costs and benefits) and also provided a holistic evaluation (each evaluation was done on a scale from 1 to 10, the higher the better).

Results

A total of 160 students participated in the laboratory experiment, a quarter of whom were architecture students. 80 participants were assigned to 20 groups that followed a sequential planning procedure (work group members communicated exclusively in one-on-one meetings—as described in the previous section); the remainder 80 participants were assigned to 20 groups that followed an integrated planning procedure (work group members were placed together in one room—as described in the previous section).

The average holistic evaluation of the jury served as the dependent variable in our analyses as an approximation of the quality of planning groups' outputs. We argue that in building design the process effectiveness is of much higher relevance compared to process efficiency, as planning time and planning cost are negligible compared to the resulting building's life-cycle time and cost. However, our research also included evaluation of efficiency, first analyses on the data gathered in the laboratory experiment found a higher time efficiency of integrated planning teams and a higher satisfaction of the work groups with the integrated planning process (Kovacic and Sreckovic, 2012).

The independent variables gathered on an individual basis were aggregated to group-level variables by the common approach of calculating the averages (Cummings, 2004). Table 1 provides descriptive statistics of the independent and dependent variables at the level of analysis (i.e. the group level). Note, however, that the averages at the individual level are equal to the averages at the group level as all group sizes are equal.

From Table 1 one can observe that the participants on average were about 23 years old, in their fifth to sixth semester and already possessing around eight months of professional experience. About 30% of the participants were female.

Table 2 presents the correlations of the independent variables. Not surprisingly, age, the semester of study and the months of professional experience are positively correlated. Moreover, the strong correlation of the personality threats: agreeableness and the attitudes towards team work is comprehensible. Interesting is the striking positive correlation between group averages of self-documented level of perceived workload and the level of perceived conflict, indicating that workload, work distribution and conflict go hand in hand during the planning processes.

Regression analyses were started with a base model (model 0 in Table 3) that considers the effects of the planning procedure as a dummy variable (0 for sequential 1 for integrated planning) and the control variables. Consistently with initial and previous univariate analyses, we found no direct effect of the planning procedure on the outcome quality of the design process (Kovacic *et al.*, 2011). Also control variables, i.e. the average age and the portion of female group members, have no impact on the outcome.

Model 1 considers the effect of skills and experience and finds weakly ($p < .1$) significant contribution of the average drawing skills and the average study progress. These first two models (model 0 and model 1) did not fit, however, model 2 keeping drawing skills and study progress as explanatory variables and adding the four general personality traits—as well as their interaction with the planning procedure used by the group—leads to the first reasonably fitting model 2, with adjusted multiple R^2 of 0.27, F-statistic 2.329, significant at $p < .05$.

In model 2, average drawing skills lead to higher evaluation ($p < .05$); furthermore, groups with higher values for conscientiousness (PCO) reached significantly inferior results ($p < .01$) in integrated planning procedures, while in general high conscientiousness of the group has no such effect. Adding the planning specific personality traits, such as attitudes towards team work, cooperation and communication (and

Table 1 Descriptive statistics for dependent and independent variables at the group level

	Mean (SD)	Min	1. Q	Median	3. Q	Max
Age (years)	22.870 (2.102)	20.500	21.690	22.500	23.000	29.750
Female	0.294 (0.203)	0.000	0.250	0.250	0.500	0.750
Study (semesters)	5.650 (2.558)	3.250	4.188	5.000	6.000	16.500
Drawing skills	3.131 (0.420)	2.250	3.000	3.000	3.312	4.000
Experience (months FTE)	7.888 (7.746)	0.000	3.438	4.500	10.542	27.500
Extraversion PEI	3.331 (0.262)	2.725	3.194	3.362	3.506	3.775
Agreeableness PAG	3.826 (0.240)	3.200	3.700	3.900	3.956	4.275
Conscientiousness PCO	3.746 (0.235)	3.200	3.544	3.800	3.931	4.175
Openness POE	3.650 (0.207)	3.275	3.450	3.663	3.775	4.100
Team work STW	3.789 (0.243)	3.333	3.604	3.806	3.917	4.472
Communication SCM	3.982 (0.222)	3.625	3.833	3.958	4.135	4.417
Cooperation SCP	3.328 (0.204)	2.625	3.219	3.312	3.500	3.675
Workload	4.031 (0.532)	2.061	3.652	4.143	4.382	4.849
Conflict	4.034 (0.533)	2.030	3.674	4.157	4.392	4.854
Jury	6.255 (1.161)	3.800	5.550	6.500	7.200	8.200

Note: FTE, full time equivalent.

Table 2 Correlation of independent variables

	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	−0.07	0.78***	0.21	0.58***	0.18	−0.20	−0.07	0.09	−0.20	−0.03	−0.12	0.04	0.04
2. Female		−0.05	−0.13	0.04	−0.06	0.19	−0.23	−0.03	0.12	−0.33*	−0.12	0.01	0.02
3. Study			−0.05	0.59***	0.18	−0.07	−0.07	0.14	−0.19	−0.14	−0.06	−0.07	−0.07
4. Drawskill				0.36*	0.07	−0.13	0.15	0.12	0.14	0.19	0.15	0.24	0.24
5. Experience					0.34	−0.23	−0.12	−0.02	−0.07	−0.15	−0.12	−0.01	0.00
6. PEI						0.36*	0.27	0.34*	0.37*	0.15	−0.20	−0.20	−0.22
7. PAG							0.46**	0.30	0.63***	0.38*	−0.15	0.05	0.04
8. PCO								0.46**	0.35*	0.50**	0.22	−0.13	−0.13
9. POE									0.17	0.39*	−0.24	−0.01	−0.01
10. STW										0.40*	−0.15	−0.09	−0.09
11. SCM											0.01	0.08	0.09
12. SCP												−0.07	−0.06
13. Workload													0.99***
14. Conflict													

Significance levels:
*$p < .05$.
**$p < .01$.
***$p < .001$.

Table 3 Overview of the regression analyses

	Model 0	Model 1	Model 2	Model 3
Intercept	3.520	2.704	−7.645	−9.102
	(−1.672)	(1.644)	(−1.204)	(−2.057)*
Procedure	0.198		10.618	6.750
	(−0.54)		(1.208)	(0.995)
Age	0.128			
	(1.449)			
Female	−1.034			
	(−1.138)			
Drawing skill		0.931	0.947	0.917
		(1.907)	(2.078)*	(2.362)*
Study		0.181	0.113	0.092
		(1.955)	(1.588)	(1.483)
Experience		−0.049		
		(−1.510)		
POE			1.551	2.083
			(1.150)	(2.394)*
PCO			1.949	0.971
			(1.492)	(1.010)
PEI			0.556	
			(0.505)	
PAG			−1.144	
			(−0.971)	
Procedure * POE			2.438	
			(1.259)	
Procedure * PCO			−5.580	−4.018
			(−3.233)**	(−3.002)**
Procedure * PEI			−2.362	
			(−1.404)	
Procedure * PAG			2.313	
			(0.228)	
Conflict				0.238
				(0.693)
Procedure * conflict				1.838
				(2.073)*
Mult. R^2 (adj.)	0.09 (0.02)	0.14 (0.06)	0.48 (0.27)	0.51 (0.38)
F-statistic	1.243	1.864	2.329	3.997
DF	36	36	28	31
p-Value	.308	.153	.035	.002
AIC	130.494	128.661	124.449	116.086

*p < .05.
**p < .01.
***p < .001.

their interaction with the planning procedure) did not lead to a better model and therefore is not reported, however, adding perceived level of conflict did lead to our final model 4. Given the high positive correlation of perceived workload and perceived conflict should be included in one model.

With the insights from the previous models, systematic variation led to the final model 3, which best fits the data and explains the reasons for good performance evaluation by the jury, with adjusted multiple R^2 of 0.38, F-statistic 3.997, significant at $p < .01$ and lowest with 116,086 as lowest Akaike information criterion (AIC) of all models—see Table 3.

The average drawing skills are in all models of importance ($p < .05$), the average progress in the study contributes insignificantly ($p \sim .15$) but according to adjusted lower R^2 and higher AIC in a model without this explaining variable should be kept in the model. Furthermore, a high group value for openness to experiences leads to better results.

The planning procedure, the conscientiousness of the group and its perceived level of conflict for themselves have no influence on the outcome for them alone. Only in specific planning procedures, do this personality trait and the conflict level influence the outcome, as can be derived from the significant interaction effects in model 3. Highly conscientious groups perform worse in integrative planning, which indicates that this planning procedure is adverse to their working habits. On the other hand, high conflict level leads to better results in integrated planning. This procedure seems to be able to better handle conflict and transform it into valuable outcomes.

Discussion and conclusion

The laboratory experiment reported in this paper was motivated by interest to identify the factors that influence performance in collaborative building planning. However, the analyses of the accomplished experiment did not support this general link; so we investigated the key success factors of the collaborative planning process in more detail in this paper.

Consistent with our hypothesis H1a, we found significant positive effects of group qualification—progress in the study, drawing skill and professional experience were not relevant. Attitudes towards working in groups and the planning procedure were not influential, which leads us to reject hypotheses H2 and H3. The through literature assumed direct link between integrated planning and high performance—through integration and coordination of various disciplines throughout the project (Faniran *et al.*, 2001); the involvement of the whole project team in initial design, joint decision-making and holistic thinking (IWHBD, 2008), therefore, was not found. This is also consistent with preliminary analyses (Kovacic and Sreckovic, 2012) which also found no direct positive influence of integrated planning on the outcomes reached with this planning procedure. In accordance with literature and our hypothesis H4d, a high level of openness to experience is beneficial to group performance as it enables more creative and novel outcomes. The other three personality traits, extraversion, agreeableness and consciousness, did not show a direct positive influence on team performance as hypothesized. Previous studies on the influence of personality traits on team performance revealed that this relation is highly task dependent. The creative task of building design seems to hinder the exploitation of positive effects like extroversion, agreeableness and consciousness as already mentioned in the second section.

One interesting result is the significant interaction effects with the planning procedure we found in our regression analysis. On the one hand, groups with high conscientiousness reach worse results with the integrated planning procedure; on the other hand, groups that perceive a high level of conflict—or workload as these two measures were highly correlated as shown in Table 2—reach better results with the integrated planning procedure. What can be the reasons for these findings and what is their relevance for theory and practice? Integrated planning could be interrupting for the accomplishment of tasks in a manner in which the highly conscientious group members prefer and therefore lead to inferior results. Furthermore, group think phenomenon might undermine the identification of the participants with, and the feeling of responsibility for, the results achieved in the work group. It is therefore necessary to adjust the planning procedure to individual personality traits to avoid such effects, for example, by the use of IT (like building information modelling) in the group coordination, so that the different professions can work together in some phases of the planning process, but in others can focus on their own subtasks.

Concerning conflict and workload, both are not by themselves negative to a work group result; by contrast, if handled correctly a high workload can lead to a lot of work done and conflicts, if settled successfully, lead to an integration of different perspectives and thereby probably better results. This seems to be the case when high perceived conflict and workload are dealt with by integrated planning procedures. The easier interaction makes it easier to reallocate and coordinate workload in the group and also to exchange information and discuss different perspectives. Both can result in positive impulses for the resulting output.

Based on the results, we can derive some recommendations for AEC practice. Before engaging in a design process, a personality trait analysis of team members could be briefly assessed. Based on the assessment, a careful design of the design process can be outlined—for example, as a succession of interactive workshops, and individual, concentrated problem-solving or modelling phases. Further on, a moderator should be employed in the initial team-forming phase, in order to initiate the team forming, to design the communication and to give necessary space for expressing the ideas to the more introverted team members. This could be especially encouraging for the engineers, who often prefer to work within the restrictions of a given design, due to their professional culture. However, bringing in new ideas based on the specific e professional expertise and contribution, leads to better results in an adequate planning procedure. Furthermore, establishment of a culture of positive conflict is necessary, for which again a moderator could be employed, as supervisor and process facilitator.

In planning projects where experts represent firms in inter-firm collaboration, the personality of the group members from different firms still has a significant impact on group functioning; however, organizational culture might be an influencing factor as well in such constellations. The existence and strength of this relation calls for future research.

The presented analyses focus on aggregate work group characteristics (average values of all members as a measure for the whole group). Diversity might be a critical point in this regard. For group composition it is an interesting question whether the diversity among group members in demographics, background, experience, etc. is beneficial or harmful to the success of the work group and whether different planning procedures can help to realize or avoid these positive or negative effects.

Moreover, the presented study faces several limitations, which should be addressed in future research to deepen our understanding of the influence of personality traits and planning procedures on outcome quality. Though the experiment shows a satisfying sample size it is based on only one planning project; therefore it should be replicated with tasks of various sizes and complexities to enforce confidence in the obtained results. Furthermore, as students took over the roles in the planning teams, generalizability of the results to the professional sector might be a critical issue. The use of undergraduate participants in laboratory experiments often is the only way to accomplish studies that focus on process design, as an intervention in real planning processes could cause harmful and expensive outcomes and additionally cannot be observed and analysed easily. However, experiments with expert participants, for example, as part of postgraduate programmes, could allow validating the findings of this study. As professionals are typically not available very easily these studies would normally have fewer participants, which makes statistical analyses hard but allows for detailed case studies on planning processes, which explicitly take into account personality traits and planning procedures and their effect on outcomes.

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