Preference-based Accommodation Strategy

A pilot study in scheduling and planning at the Delft University of Technology

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Purpose: One of the long-standing issues in the field of corporate real estate management is the alignment of an organization's real estate to its corporate strategy. Despite extensive research, existing approaches have not had much uptake in practice and fall short in a number of aspects. This paper describes the test of Preference-based Accommodation Strategy (PAS) as an approach to achieve alignment.
Design/methodology/approach: In order to test the PAS methodology, a model is designed and tested according to formal design principles. The objective is to determine if users are able to determine their preferences as prescribed by the methodology, and if users are able to use the methodology to yield a better design result.
Findings: The tests with the participants reveal that users are able to determine their preferences as prescribed, and that they are also able to yield a better design result by using the PAS methodology. In addition, the PAS methodology is also evaluated positively by the participants.
Implications for research: The positive results suggest that PAS is a suitable approach to achieve alignment. Additionally, this paper provides evidence that PAS can be used in the context of university campus management to inform, involve and convince various stakeholders.

Keywords: Corporate real estate management, alignment, decision-making, decision support system, preference measurement

Introduction

This paper reports the second test of the PAS methodology at the Delft University of Technology. PAS, short for Preference-based Accommodation Strategy, is a methodology that enables the user to select the best portfolio design given a set of performance criteria and the performance of each portfolio on these criteria. This methodology has recently been developed by Arkesteijn and Binnekamp (2013) (1).

PAS has been developed as a methodology to be used in Corporate Real Estate Management (CREM). In CREM, the objective is to optimally attune corporate accommodation to organizational performance (De Jonge, 1994: p. 15). According to Heywood (2011: p. 2) this alignment is a long-standing issue. Despite extensive research, existing approaches have not had much uptake in practice and fall short in a number of aspects (Heywood, 2011: p. 2).

Arkesteijn and Binnekamp (2013) contend that the selection of a strategy (i.e. a combination of interventions) to achieve alignment can be done by using multiple criterion decision analysis (MCDA). In a survey of existing alignment models, they find that these models either do not have a well-defined procedure to select the best strategy, or do not use proper preference measurement to select the best strategy. The methodology proposed in their paper (PAS) resolves these issues. The test described in this paper is essential in order to determine whether the methodology is usable and if it is possible to select the best design.

In methodological terms, PAS sets itself apart by combining quantitative data and qualitative assessment. For example, normally one would be asked to rate the average walking distance to a lecture on a scale from 1 to 5, with 1 indicating "very bad" and 5 indicating "very good." Then, when the data is collected, one can only assess (on an ordinal scale) that the users are either satisfied or unsatisfied, but not what is the most desired value for walking distance to a lecture. In PAS this problem is solved by *assigning* a preference rating to a walking distance: for instance, a walking distance of 5 minutes yields a preference rating of 100 and a walking distance of 10 minutes yields a preference rating of 0. This will be explained in more detail below.

Preference-based Accommodation Strategy

In Corporate Real Estate Management, multiple users have an influence on which intervention is the best course of action. The selection of the best set of interventions is therefore a multi-criteria group decision making problem. Multi-criteria decision analysis (MCDA) enables the decision makers to aggregate all the performance criteria into an overall performance rating: by using MCDA, they can determine the overall performance of their current portfolio on user preferences, and by extension the intervention that performs best.

Arkesteijn and Binnekamp (2013) propose the following methodology in order to select the best set of real estate interventions:

1. Specify the decision variable(s) (2) each user is interested in.
2. Rate the user's preferences for each decision variable as follows:

   a) Establish (synthetic) reference alternatives which define 2 points of a Lagrange curve:
   I. Define a 'bottom' reference alternative, the alternative associated with the value for the decision variable that is least preferred, rated at 0. This defines the first of the curve, (x_0, y_0).
   II. Define a 'top' reference alternative, the alternative associated with the value for the decision variable that is most preferred, rated at 100. This defines the second point of the curve, (x_1, y_1).

   b) Rate the preference for an alternative associated with an intermediate decision variable value relative to the reference alternatives. This defines the third point of the curve (x_2, y_2). Figure 1 displays an example of a Lagrange curve.

3. To each decision variable assign user's weight. Assign weights to each user.
4. Determine the design constraints.
5. Generate (all) design alternatives (using the number of buildings and allowed interventions). Then use the design constraints to test their feasibility.
6. Use the PFM (3) algorithm to yield an overall preference scale of all feasible alternatives. In this case, an algorithm to yield an overall preference scale was not yet available: therefore users designed alternatives manually with the objective to achieve the highest overall preference score.

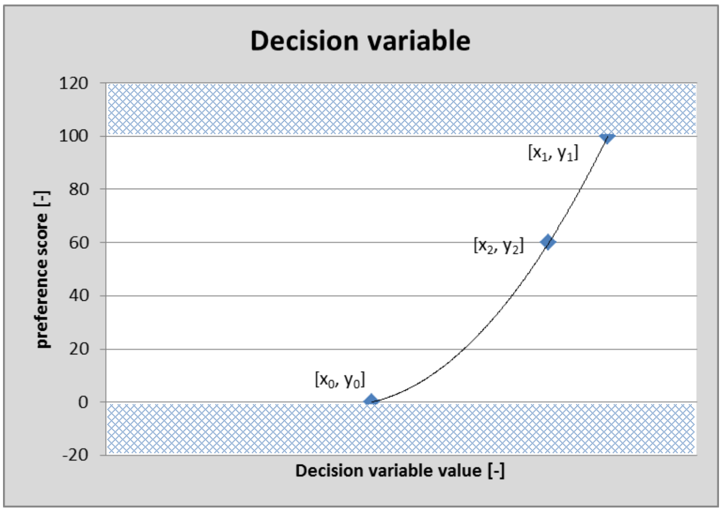

Figure 1 – Example of a Lagrange curve

Case Description

The Delft University of Technology (DUT) is located in the city of Delft, a small city between the large cities of Rotterdam and The Hague in the Western part of the Netherlands. The university currently houses 14,500 students and 7,600 employees (including 1,600 guests). In terms of land and buildings the DUT is the second largest university in the Netherlands: in 2007 its building portfolio consisted of 500,000 sq. m^2 gross floor area. In addition the university owns approximately 170 hectares of land.

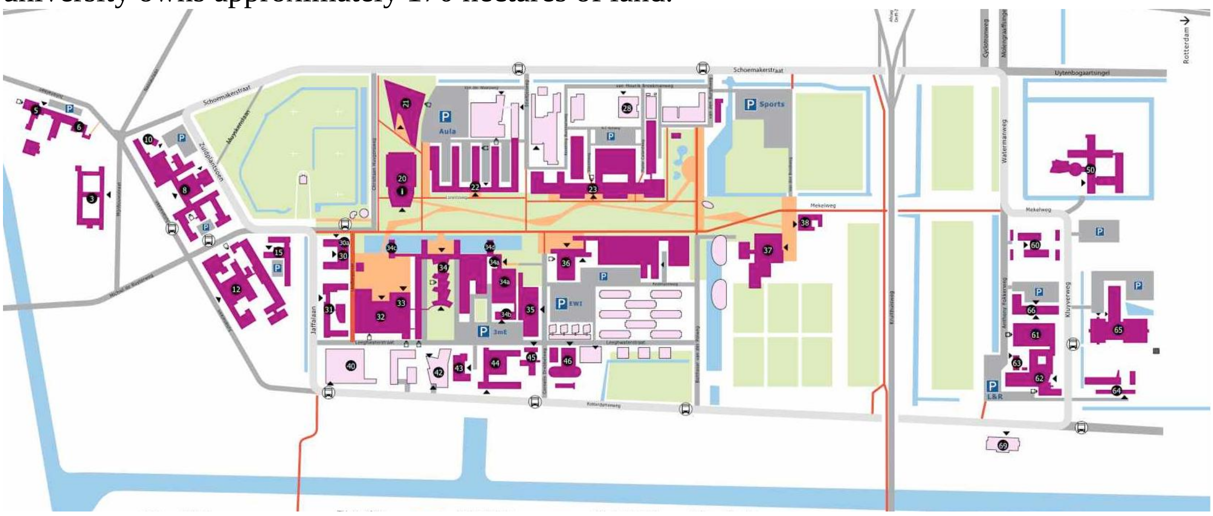

Figure 2 – Delft University of Technology, campus map

All university buildings are located on a campus south of the city centre, between a Canal (the Schie) and a highway (A13). The campus consists of three areas – TU North, TU Central and TU South – each has a unique character. More than 75 percent of the total surface area of the university buildings is located in TU Central, the area designated for education and research. TU South is designated for companies affiliated with the university's research activities. TU North accommodates the Architecture Faculty, residential facilities, recreational facilities and small enterprises, owing to the area's close proximity to the city centre and architectural features of the buildings, which date from the early 20th century.

Research by Den Heijer (2011) and AOS Studley (2012) show that in comparison to other Dutch universities, the DUT has a relatively inefficient CRE portfolio. Additionally, a substantial part of its portfolio has been built in the 1960s and 1970s and requires large-scale renovation. The university has therefore made plans to renovate the campus, to reduce the size of its portfolio, and to lower its accommodation costs. The university's real estate department (FMRE) has expressed the desire to develop these plans together with the various stakeholders on the campus, to determine which improvements are necessary and where space can be used more efficiently. Therefore a pilot study utilizing the PAS methodology was undertaken.

The case reported on in this paper specifically concentrates on the university's large lecture halls. The university's lecture halls are subject to the following problem(s):

- The current supply of lecture halls does not meet present-day requirements with regard to facilities and capacity;
- The university is starting a new curriculum next year, which will lead to a changing demand for lecture halls;
- There are too little types of educational facilities to accommodate this changing demand;
- The current supply is being used ineffectively.

Figure 3 displays the university's portfolio of large lecture halls. The numbers inside the circles indicate the capacity of each lecture hall. Two buildings in the portfolio have five lecture halls a piece. The orange lecture halls are lecture halls that are currently in use for educational activities. The red lecture hall is only used for special events. The white lecture hall is not existent as of yet, but can be built there as part of a new faculty building.

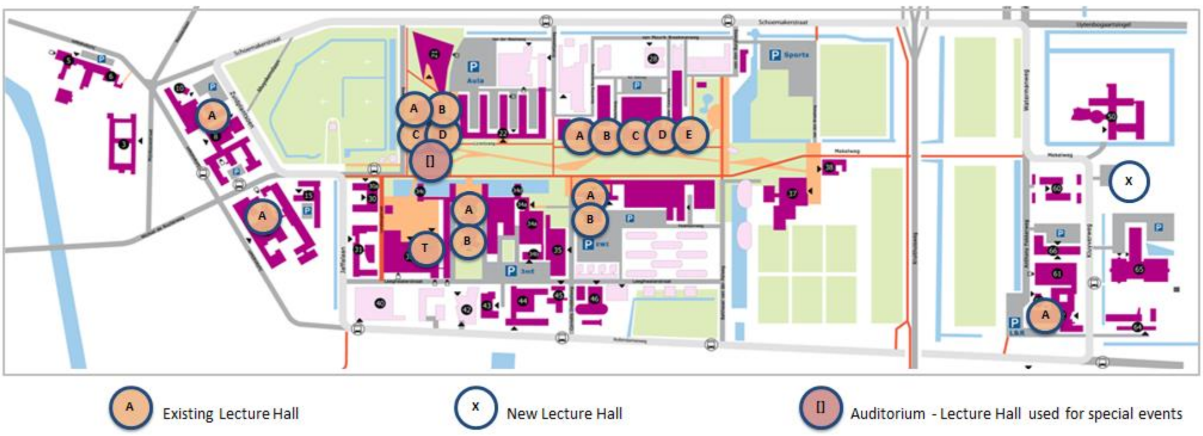

Figure 3 - Delft UT, large lecture halls (160+ seats)

Research Methodology
By establishing preferences according to the PAS methodology and relating them to the performance of objects, we are designing a model: a simplified representation of reality. The construction of this model is done in order to solve a predefined problem (described in the previous section) and it is done in a specific way (the PAS methodology).

In order to design the model, the steps of a design process as described by Dym and Little (2004) is used. The user requirements, constraints and functions are collected in interviews per participant, after which the model is constructed and tested in workshops. In order to refine and optimize the design of the model, users are permitted to readjust their requirements, constraints and functions, after which the model is tested once again.

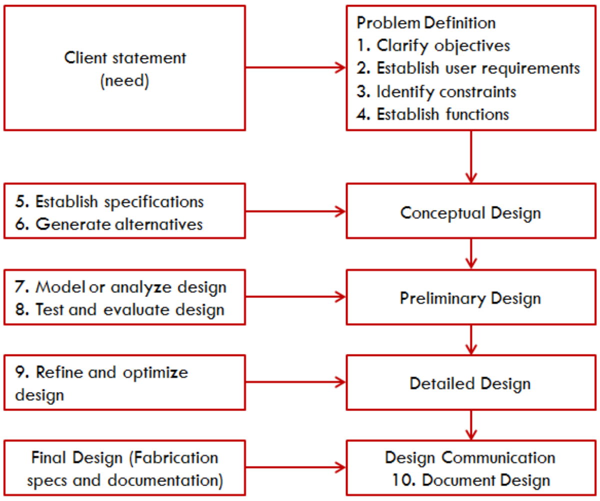

Figure 4 - Steps of a design process (Dym and Little, 2004)

In order to determine whether the PAS methodology is an appropriate methodology to solve the problem, two questions must be answered:

1. Are users able to determine their preferences as prescribed by the methodology?
2. Are users able to use the methodology to yield a better design result?

These questions are answered primarily by completing the PAS methodology and secondarily by evaluating the PAS methodology with the participants. This is done by using insights of the soft OR-method by Joldersma and Roelofs (2004). After each workshop, participants are requested to answer the following questions:

- What are your experiences with the model?
- What do you think of the attractiveness of the method?
- What is your perception of the effectiveness of the method?

Step 1: Specify the decision variable(s) the user is interested in
In order to determine which users were to participate in the pilot, the CREM model by Den Heijer (2011) was used (figure 4). According to Den Heijer it is important to involve each of these four stakeholder perspectives in the decision-making process, so as to incorporate all relevant information and weigh costs and benefits in the broadest sense (Den Heijer, 2011: p. 108). Figure 6 displays the stakeholders that participated in the pilot. Some stakeholders

consisted of multiple participants (e.g. Education and Student Affairs) whilst others consisted of only one participant (e.g. Board of Directors).

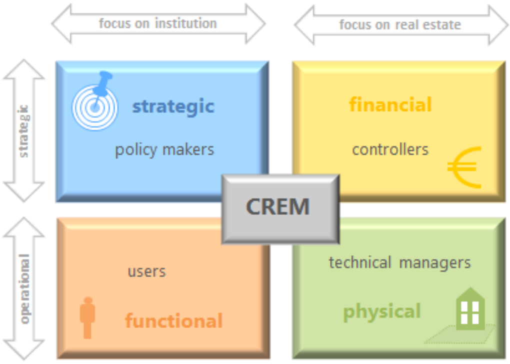

Figure 5 - Stakeholder perspectives (Den Heijer, 2011)

	Stakeholder	Examples of Criteria
	Board of Directors	Student satisfaction, teacher satisfaction
	Directors of Education	Students in own faculty, availability SMARTboard
	Facility Management and Real Estate	Exploitation costs, occupancy rate
	Student Council	Evening lectures, lectures in own faculty
	Teacher Board	Student walking distance, availability SMARTboard
	Education and Student Affairs	Occupancy rate, Match students/capacity lecture hall

Figure 6 - Participating stakeholders in case 2.

The criteria defined by each stakeholder (table 1) reveal that the performance of the university's lecture halls depends only partly on the amenities available in the lecture hall. A large part of the performance also depends on the way the lecture halls are used by the organisation. The users of the lecture halls are generally concerned about the amenities in the lecture halls and the vicinity of the lecture hall to their workplace. The technical managers focus on the efficiency of the portfolio (occupancy rate, costs); the board of directors is interested in both efficiency and satisfied users.

With regard to the amenities in lecture halls, the decision variables reveal that some amenities are found to be important or even necessary by multiple users (e.g. Collegerama, four-quadrant beamer), whereas other amenities (e.g. power outlets for laptop use, comfortable chairs) are not mentioned at all.

Step 2: Determining preferences

For each decision variable, the stakeholders determined a bottom reference alternative (x_0, y_0), a top reference alternative (x_1, y_1) and an intermediate reference alternative (x_2, y_2). The preference ratings displayed in the table correspond with the preference ratings at the end of the second workshop.

As an example, figure 7 displays preference ratings of the participant 'Education and Student Affairs to the decision variable 'occupancy rate.' In this case, the bottom reference alternative (x_0, y_0) is set at 100 percent, because the participant has no flexibility left in the schedule if the occupancy rate of the lecture halls is 100 percent. The top reference alternative (x_1, y_1) is set at 70 percent, because the department's experience is that this leaves enough room in the schedule for extracurricular and/or unforeseen events.

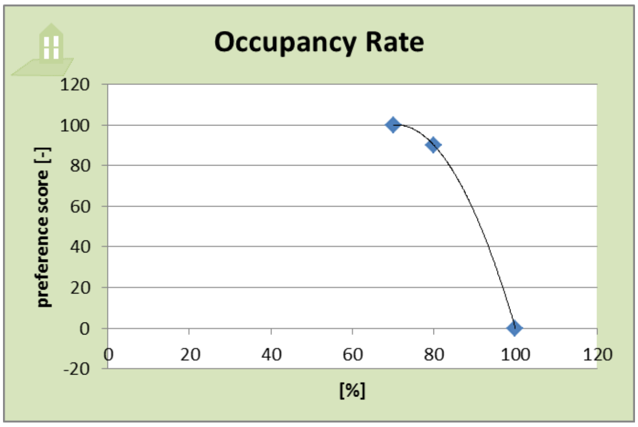

Figure 7 – Lagrange curve relating preference rating to the occupancy rate (decision variable 32) of the university's portfolio of lecture halls

Decision maker	Decision variable	$[x_0, y_0]$	$[x_1, y_1]$	$[x_2, y_2]$
Board of Directors	1 Education in classrooms and project rooms (%)	[0, 0]	[50, 100]	[40, 80]
	2 Student satisfaction (%)	[45, 0]	[85, 100]	[75, 80]
	3 Teacher satisfaction (%)	[45, 0]	[85, 100]	[75, 80]
	4 Occupancy rate (%)	[30, 0]	[70, 100]	[55, 80]
Directors of Education	5 First year students: lectures in own faculty (%)	[25, 0]	[90, 100]	[70, 75]
	6 Second year students: lectures in own faculty (%)	[20, 0]	[60, 100]	[40, 70]
	7 Third year students: lectures in own faculty (%)	[0, 0]	[20, 100]	[10, 4]
	8 Ratio between students and lecture hall capacity	[150, 0]	[100, 100]	[120, 60]
	9 Availability of four-quadrant beamer (%)	[30, 0]	[100, 100]	[60, 80]
	10 Availability of blackboard and beamer (%)	[80, 0]	[100, 100]	[90, 60]
	11 Availability of flexible chairs (%)	[0, 0]	[30, 100]	[15, 60]
	12 Education in small classrooms (%)	[2, 0]	[12, 100]	[8, 70]
Student Council	13 Amount of lectures recorded (Collegerama) (%)	[75, 0]	[100, 100]	[80, 30]
	14 Amount of lectures in the evening	[2, 0]	[0, 100]	[1, 40]
	15 Amount of movements between buildings	[3, 0]	[0, 100]	[2, 20]
	16 Lectures in own faculty (%)	[50, 0]	[100, 100]	[75, 60]
	17 First year students: lectures in own faculty (%)	[25, 0]	[90, 100]	[75, 70]
	18 Second year students: lectures in own faculty (%)	[20, 0]	[80, 100]	[50, 70]
	19 Third year students: lectures in own faculty (%)	[0, 0]	[50, 100]	[25, 20]
	20 Availability smartboard/four-quadrant beamer (%)	[20, 0]	[100, 100]	[50, 30]
	21 Flexible lecture halls (%)	[0, 0]	[30, 100]	[15, 60]
Teacher	22 Standard equipment (%)	[0, 0]	[100, 100]	[50, 40]
	23 Blackboards/whiteboards (%)	[50, 0]	[100, 100]	[80, 60]
	24 Flexible chairs (%)	[30, 0]	[80, 100]	[60, 60]
	25 Walking distance for students (minutes)	[15, 0]	[5, 100]	[10, 25]
	26 Amount of lectures recorded (Collegerama) (%)	[0, 0]	[100, 100]	[80, 90]
	27 On-site assistance (minutes)	[10, 0]	[2, 100]	[5, 20]
	28 Assistance in transport of teaching materials (hours)	-	-	-
	29 Reservation of parking spots (%)	[0, 0]	[100, 100]	[20, 20]
E&S Affairs	30 Walking distance for students (minutes)	[15, 0]	[5, 100]	[10, 50]
	31 Ratio between students and lecture hall capacity	[150, 0]	[100, 100]	[125, 80]
	32 Occupancy rate (%)	[100, 0]	[70, 100]	[80, 90]
	33 Functionality of lecture hall equipment (%)	[95, 0]	[99, 90]	[100, 100]
FMRE	34 Occupancy rate (%)	[0, 0]	[70, 100]	[40, 50]
	35 Ratio between students and lecture hall capacity	[50, 0]	[90, 100]	[75, 80]
	36 Exploitation costs (€)	[130, 0]	[100, 100]	[110, 80]

Table 1 – Decision variables and their respective preferences.

Step 3: Assigning weights

The weights assigned to each decision variable are displayed in the figure below. The weights between each stakeholder were determined by the board of directors to be split equally: therefore each stakeholder has a weight of 16.67%.

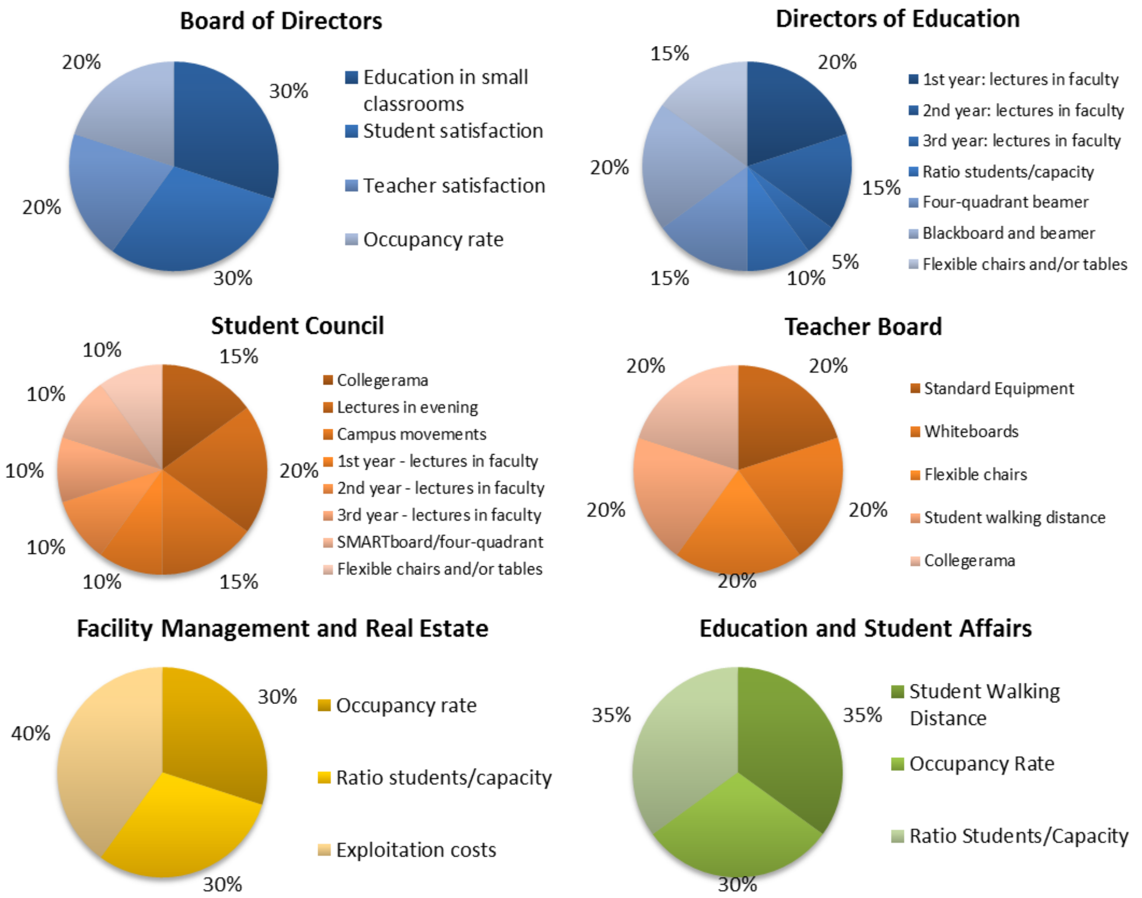

Figure 8 - Criteria per stakeholder and their respective weights

Step 4: Determining Design Constraints

A total of 10 design constraints were determined by the stakeholders, mostly related to scheduling issues rather than real estate issues. What the design constraints also reveal is that for E&S Affairs the priority is to schedule all the university's activities within the specified constraints, after which a certain efficiency is desirable (see decision variables).

Decision maker	Design Constraint	Incorporated in design process
Student Council	1 Two-way interaction with the teacher at all times	X
	2 The equipment in the lecture hall always functions properly	
	3 The teacher is able to handle the equipment	
	4 Sufficient acoustic quality	
	5 The amount of students present cannot exceed the lecture hall capacity	X
Teacher	6 Possibility for demonstrations (experiments)	
E&S Affairs	7 The DUT must have enough capacity to accommodate all mandatory activities	X
	8 The maximum amount of scheduled hours per student per day is eight hours	X
	9 Mandatory courses cannot be scheduled at the same time	X
	10 FMRE must announce a reduction in capacity 5 months in advance.	

Table 2 – Design constraints

In order to be able to design based on constraints and decision variables such as occupancy rate, percentage of lectures in own faculty, sufficient capacity, etc. a scheduling model was made. The scheduling model utilizes linear programming (LP) to allocate activities to spaces. LP allocates these activities to spaces based on a single objective: e.g. minimal costs or minimal walking distance. The mathematical notation of this problem, the limited transportation problem, is as follows:

Maximize $$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} X_{ij}$$

Subject to: $$\sum_{j=1}^{n} a_{ij} X_{ij} \geq d_i \qquad X_{ij} \geq 0$$

for i = 1, 2, m   for i = 1, 2, m and j = 1, 2, n

$$\sum_{i=1}^{m} a_{ij} X_{ij} \leq s_j \qquad a_{ij} = \{0,1\}$$

for j = 1, 2, n   for i = 1, 2, m and j = 1, 2, n

This mathematical notation is displayed in its simplest form in table 3 and 4. Both tables represent the same problem of allocating two courses to two rooms for one hour. Table 3 highlights a demand constraint: course 1 requires one hour, in room 1 or 2 (X_{11} or X_{12}). This requirement must be either fulfilled or exceeded, or else the solution is not feasible. Course 1 can be allocated to both rooms, but not to neither one of them.

	Course 1	Course 2		
Room 1	X_{11}	X_{21}	<=	s_j
Room 2	X_{12}	X_{22}	<=	s_j
	>=	>=		
	d_i *(1)*	d_i *(1)*		

Table 3 – Scheduling model, demand constraints

Table 4 highlights a supply constraint: in one hour, room 1 can only accommodate one hour (X_{11} or X_{21}). This requirement cannot be exceeded, or else the solution is not feasible. Room 1 can host the lecture of course 1, course 2, or neither; but it cannot host both.

	Course 1	Course 2		
Room 1	X_{11}	X_{21}	<=	s_j *(1)*
Room 2	X_{12}	X_{22}	<=	s_j *(1)*
	=	=		
	d_i	d_i		

Table 4 - Scheduling model, supply constraints

Finally, each moment in time and space (X_{ij}) relates to a variable a_{ij} which determines if that moment is usable. For instance, a_{ij} can be set to 0 if the teacher is unavailable, if the students have other lectures, or if the room is not suitable. If a_{ij} is set to 0, a course cannot be scheduled at that moment (X_{ij}). The variable a_{ij} makes it possible to incorporate the design constraints 5, 8 and 9 (table 2) when making a schedule. In the PAS model used in the workshop, this principle was extended to make a schedule for all the university's lectures in large lecture halls for a week.

Step 5: Generating Alternatives

In PAS, the main objective of designing alternatives is to maximize the overall preference score of the portfolio, i.e. the score on each criterion given by the stakeholders. In this particular case two types of interventions are possible organisational and real estate interventions. With regard to the *schedule*, the following organisational interventions are possible:

1. Set boundary conditions on the percentage of lectures in the own faculty
2. Enable/disable scheduling in the evening hours
3. Enable/disable scheduling in the lunch hours
4. Set the allowed walking distance between lectures to 5, 10 or 15 minutes.
5. Enable/disable the new education programs in the bachelor phase, which will lead to less lectures
6. Set the amount of options given by the teacher for a suitable moment to high, medium or low
7. Toggle the amount of total students on the campus

Table 5 shows the values of these interventions in the current situation and in the design result of the second workshop.

Table 5 – Scheduling result, current situation and design.

	Current		**Design (Future)**	
Variable	**Setting**	**Scheduling result**	**Setting**	**Scheduling result**
1a First-year students in own faculty	Not fixed	47%	Fixed at 65%	65%
1b Second-year students in own faculty	Not fixed	28%	Fixed at 40%	40%
1c Third-year students in own faculty	Not fixed	15%	Fixed at 15%	15%
2 Lectures in evening hours	Off	0%	Off	0%
3 Lectures in lunch hours	Off	0%	Off	0%
4 Allowed walking distance	5 minutes	4.7 minutes on average	15 minutes	5.2 minutes on average
5 New bachelor programs	Off	496 lectures per week	On	425 lectures per week
6 Amount of options given by teacher	Low	6,830 possible time slots for 496 lectures	High	12,639 possible time slots for 425 lectures
7 Amount of students	100%	-	100%	-

In the workshops, the first objective for the participants was to maximize the amount of lectures in the own faculty. Because fixing these values leads to inflexibility in the schedule, other variables were set to increase flexibility: adding new bachelor programs, increasing walking distance and the amount of options (in time) given by the teachers. With regard to *real estate*, a range of interventions could be applied to each lecture hall:

0 Remove lecture hall
1 Do nothing
2 Renovate lecture hall (by doing one or more of the following)
- a. Add power sockets;
- b. Add internet;
- c. Add four-quadrant beamer;
- d. Add blackboard;
- e. Add whiteboard;
- f. Add smartboard;
- g. Add collegerama (recording device);
- h1. Add swiveling chairs;
- h2. Add flexible chairs and tables.

3 Add new lecture hall

Table 6 – Portfolio result, current situation and design

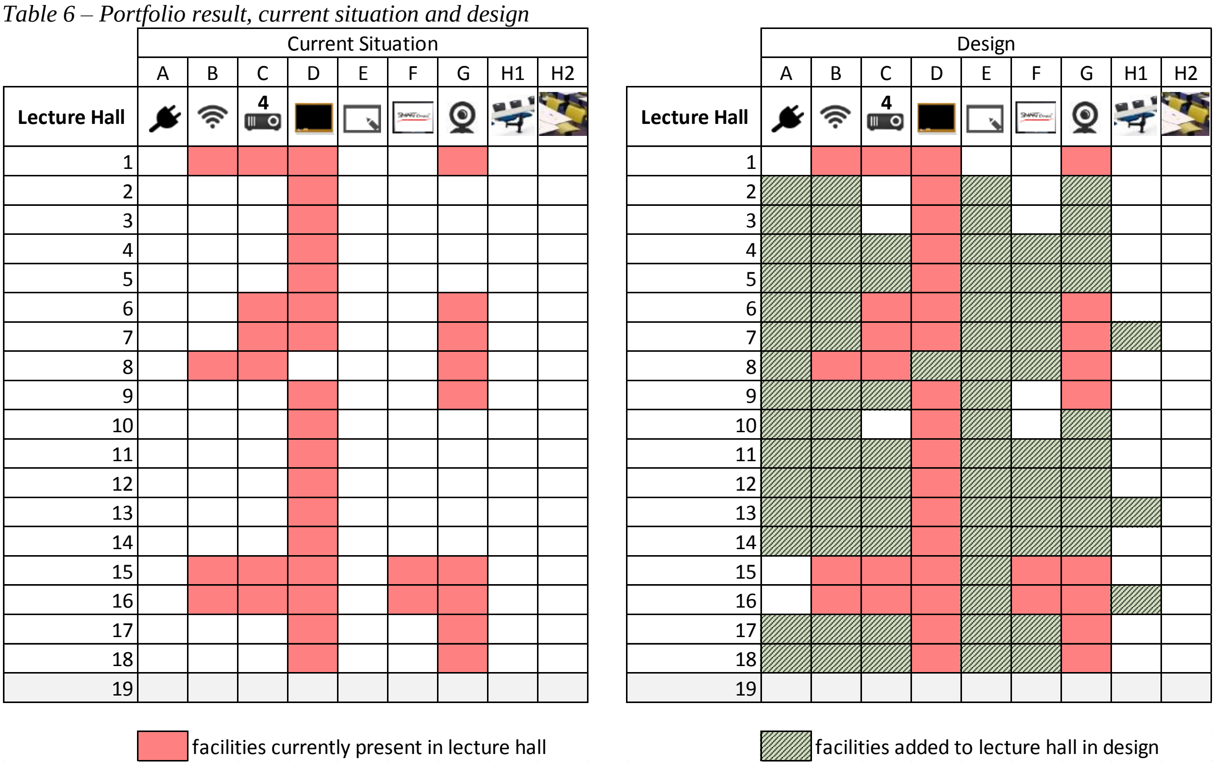

Table 6 displays the portfolio of lecture halls in the current situation and the design result. With the exception of lecture hall 1 all the existing lecture halls have been renovated. Lecture hall 19 could have been added to the portfolio if necessary, but in the design this option was not used. The combination of design interventions in the schedule and the lecture halls yielded the following design result per criterion.

Table 7 – Preference score of the current portfolio and future design per decision variable.

Decision maker	Decision variable	Current	Design
Board of Directors	1 Education in classrooms and project rooms (%)	87	100
	2 Student satisfaction (%)	0	43
	3 Teacher satisfaction (%)	57	88
	4 Occupancy rate (%)	100	94
Directors of Education	5 First year students: lectures in own faculty (%)	40	68
	6 Second year students: lectures in own faculty (%)	33	70
	7 Third year students: lectures in own faculty (%)	35	53
	8 Ratio between students and lecture hall capacity	25	17
	9 Availability of four-quadrant beamer (%)	0	88
	10 Availability of blackboard and beamer (%)	79	100
	11 Availability of flexible chairs (%)	0	69
	12 Education in small classrooms (%)	-	-
Student Council	13 Amount of lectures recorded (Collegerama) (%)	0	93
	14 Amount of lectures in the evening	100	100
	15 Amount of movements between buildings	66	72
	16 Lectures in own faculty (%)	0	0
	17 First year students: lectures in own faculty (%)	-	-
	18 Second year students: lectures in own faculty (%)	-	-
	19 Third year students: lectures in own faculty (%)	-	-
	20 Availability smartboard/four-quadrant beamer (%)	9	56
	21 Flexible lecture halls (%)	0	69
Teacher	22 Standard equipment (%)	92	100

	23 Blackboards/whiteboards (%)	65	100
	24 Flexible chairs (%)	0	0
	25 Walking distance for students (minutes)	100	96
	26 Amount of lectures recorded (Collegerama) (%)	69	99
	27 On-site assistance (minutes)	-	-
	28 Assistance in transport of teaching materials (hours)	-	-
	29 Reservation of parking spots (%)	-	-
E&S Affairs	30 Walking distance for students (minutes)	100	98
	31 Ratio between students and lecture hall capacity	37	25
	32 Occupancy rate (%)	37	25
	33 Functionality of lecture hall equipment (%)	-	-
FMRE	34 Occupancy rate (%)	100	88
	35 Ratio between students and lecture hall capacity	72	68
	36 Exploitation costs (€)	-	-
Total		**58**	**69**

Evaluation

During the test of the model, the process was also evaluated with the participants. Participants were asked to give their opinions regarding the experiences with the method, attractiveness of the method, and perception of effectiveness of the method.

The interviews and workshops are generally experienced very positively by the participants. All the participants have indicated that the workshop helped them to gain insight into the problem and their own criteria or those of others. Also, during the workshop they saw what the effect of their choices was: how the criteria affected the interventions and vice versa. The stakeholders were especially positive about the second workshop: bringing people together, searching together for a good solution, the interaction with each other and the model were all aspects that were rated positively. Some participants also recognized the importance of iteration in the process. The first workshop (for each individual stakeholder group separately) was rated less positively; some participants recognized that they had more time to focus on their own criteria and understanding the model. However, others did not understand the goal of the workshop or missed the discussion with other stakeholders.

The attractiveness of the method is rated highly by the participants. They find the process of interviews and workshops helpful – the interviews are a more attractive way to think about what you want than e.g. questionnaires, and the workshops are attractive when multiple participants are brought together to discuss the problem. Another attractive aspect is the use of curves. The participants describe determining curves as easy, and that the curves result in fewer emotions in the discussion and more thinking in the collective interest. What is generally found difficult is to assign preference scores; one has to estimate his/her satisfaction when a certain value is achieved. That is why the possibility to adjust criteria is so important. Designing interventions was perceived more difficult.

When asked about their perception of the method's effectiveness, the participants responded very positively. Some of them think that it helps to reach an agreement on an end result and that they will understand quicker why certain choices are made. When looking at the time spent and the results of the process, most participants respond that the process is certainly efficient compared to others, while some felt it took more time than similar processes. Recommendations include adding more students and teachers to make the results more reliable and adding a stakeholder with a vision on the future of education.

Conclusion

The main objective of this research was to test the PAS methodology, and by doing so providing an answer to two questions:

1. Are participants able to determine their preferences as prescribed by the PAS methodology?
2. Are participants able to use the methodology to yield a better design result?

Based on the results, both questions can be answered affirmatively. Each participant was able to establish criteria, assign preference ratings, determine weights and design constraints, and generate design alternatives. The result of the second workshop proves that they can use the methodology to yield a design result with a higher overall preference score than the current situation. The design increased the overall preference score of the CRE portfolio from a score of 58 to a score of 69.

The evaluation also yields positive results with regard to both research questions. According to the participants, determining preferences and refining and adjusting them in collective workshops is the attractive part of the methodology. Understanding the relation between values, preference ratings and one's actual preference is found to be difficult and costs time, but even so participants indicate that they understand quicker why certain choices are made. Not only does the design result improve as result of the workshop, but the participants think the end result is better and the process in order to reach that end result is more efficient than comparable processes.

Discussion

Whilst testing PAS as a methodology to align accommodation to organizational performance, evidence was found that supports the work by De Jonge et al. (2009). Matching supply and demand is not only a series of steps to be completed– it is a design process, in which the stakeholders must determine criteria, assign preference ratings and design alternatives multiple times in order to determine the best future match. Additionally, this paper provides evidence that PAS can be used in the context of university campus management to inform, involve and convince various stakeholders – a problem stated by Den Heijer (2011).

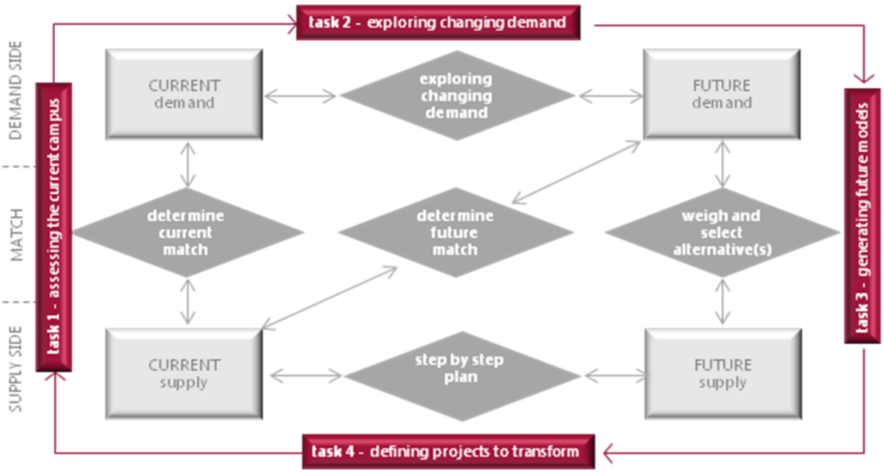

Figure 9 - DAS Frame (De Jonge et al., 2009)

In the evaluation, the participants indicated that whilst the methodology of determining preferences is easy, accurately determining how satisfied one is when a certain value is achieved is not. The best way to determine this is by making a design and by seeing what the initial value of a criterion is, by seeing what the effect is of the decisions one makes in the design, and by seeing how those decisions affect one’s stated preference. Figure 10 displays the criteria and boundary conditions given by one participant, and how the participant adjusted criteria and boundary conditions after each workshop.

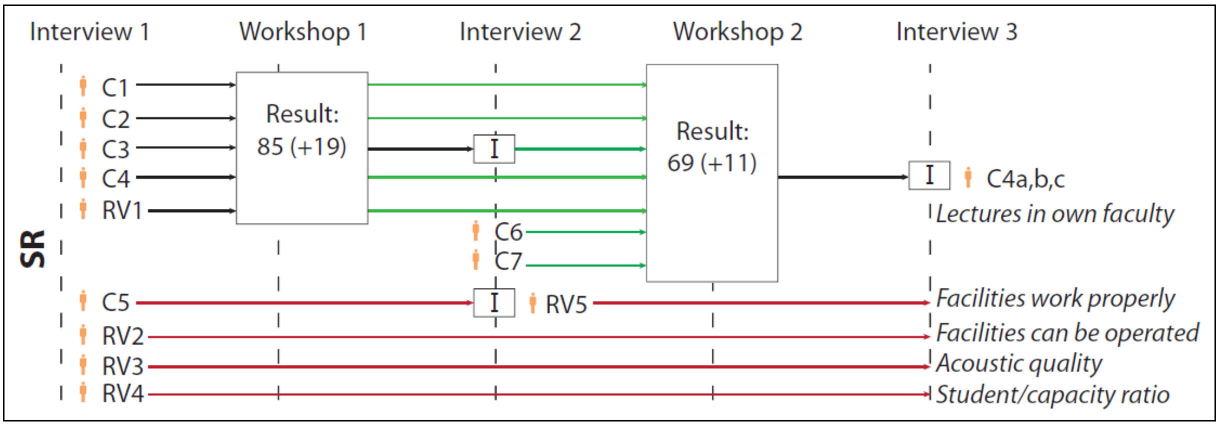

Figure 10 – Development of the criteria and boundary conditions determined by the Student Council.(4)

We argue that when using the PAS methodology, one can determine the best result by using an algorithm. However, we argue that in the future when the algorithm is available that at the same time it is also essential that the participants also design themselves in order to better understand the relation between their preferences and the performance of the portfolio. The use of such a learning process in the context of work practice and problem-solving is described by Schön (1987) as *reflection in action*.

Notes

(1) In Arkesteijn and Binnekamp (2013) the PAS methodology is termed ‘Preference-based Portfolio Design’
(2) Decision variables are also referred to as criteria in further stages of this paper.
(3) PFM, short for Preference Function Modeling, is a generic evaluation methodology developed by Barzilai (1997). This methodology was adapted so it can be used as a design methodology for real estate portfolios by Arkesteijn and Binnekamp (2013).
(4) Red indicates that the criterion (C) or boundary condition (RV) has not been incorporated into the process. In interview 2, the student council added two criteria (C6 and C7), adjusted two criteria (C3 and C5), and adjusted weights. In interview 3, the student council split criterion 4 into three separate criteria and adjusted weights.

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