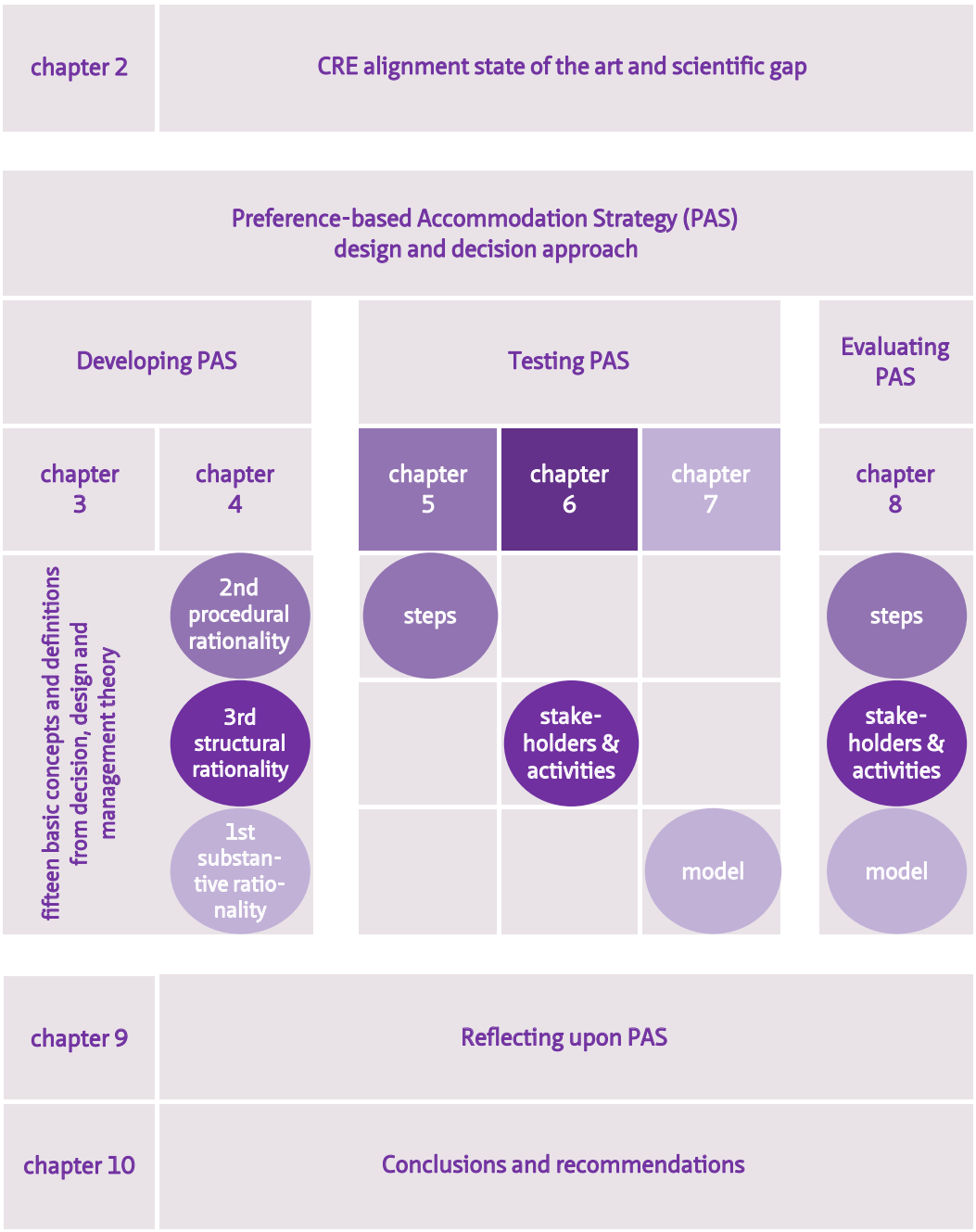
6 PAS stakeholders & activities to achieve alignment

TOC


chapter 2
CRE alignment state of the art and scientific gap
Preference-based Accommodation Strategy (PAS)
design and decision approach
Developing PAS
Testing PAS
Evaluating PAS
chapter 3
chapter 4
chapter 5
chapter 6
chapter 7
chapter 8
fifteen basic concepts and definitions from decision, design and management theory
2nd procedural rationality
3rd structural rationality
1st substan-tive ratio-nality
steps
stake-holders & activities
model
steps
stake-holders & activities
model
chapter 9
Reflecting upon PAS
chapter 10
Conclusions and recommendations

TOC

6 PAS stakeholders & activities to achieve alignment

PAS consists of three main components; steps, stakeholders & activities, and mathematical models, as explained in chapter 4. In this chapter, the *stakeholders & activities* are the focal point (see **Figure 6.1**). By explaining the interactive design process in detail, the reader understands how the stakeholders perform the activities to achieve alignment between the organization and the corporate real estate portfolio.

The stakeholders & activities are displayed in the left column of the flowchart in **Figure 6.2**. There, the stakeholders that are involved are divided in three types: the responsible management (RM), the stakeholders (S) and the facilitator and systems engineer (F & SE). They need to perform two types of *activities*: interviews and workshops. In the activity *interviews*, the stakeholders perform steps 1 to 4. In the activity *workshops*, the stakeholders perform step 5. They design an alternative corporate real estate portfolio and continue designing other alternatives until they mutually agree that the best possible alternative has been made. The activities are finished when, in the last *interview*, each stakeholder individually confirms the selection of the best alternative.

The *results* of the three pilots have been discussed in chapter 5 including the final input the stakeholders have given in the interviews for steps 1 to 4. The best alternative the stakeholders have chosen in step 6 was also presented. This alternative was designed interactively and iteratively in the *workshops* in step 5. However, *how* the stakeholders have designed this alterative has not yet been explained. Since, interactively and iteratively designing alternatives in the mathematical models is a major component of PAS this design process is explained in this chapter. This chapter shows the interfaces that the stakeholders can use when designing alternatives including instructions on how to navigate the model.

This chapter presents the pilots as follows:

- Pilot study 1: TU Delft's food facilities in paragraph 6.1;
- Pilot study 2: TU Delft's lecture halls in paragraph 6.2;
- Pilot study 3: Oracle's office locations in paragraph;
- And the pilot study comparison and conclusion in paragraph 6.4.

For each pilot study, in the first subparagraph, the *design interfaces* that the stakeholders have at their disposal, are explained. In the second subparagraph, the stakeholders workshop set up is discussed in which they use the interface to design alternatives. Lastly, in the third subparagraph, the iterative process is discussed. The iteration takes place between step 5 (designiWng alternatives) and step 1 to 4 (variables, curves, weights and constraints).

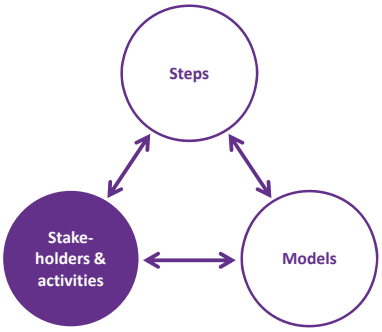


FIG. 6.1 Focus on PAS component stakeholders & activities Note adapted Arkesteijn et al., 2017, p. 245

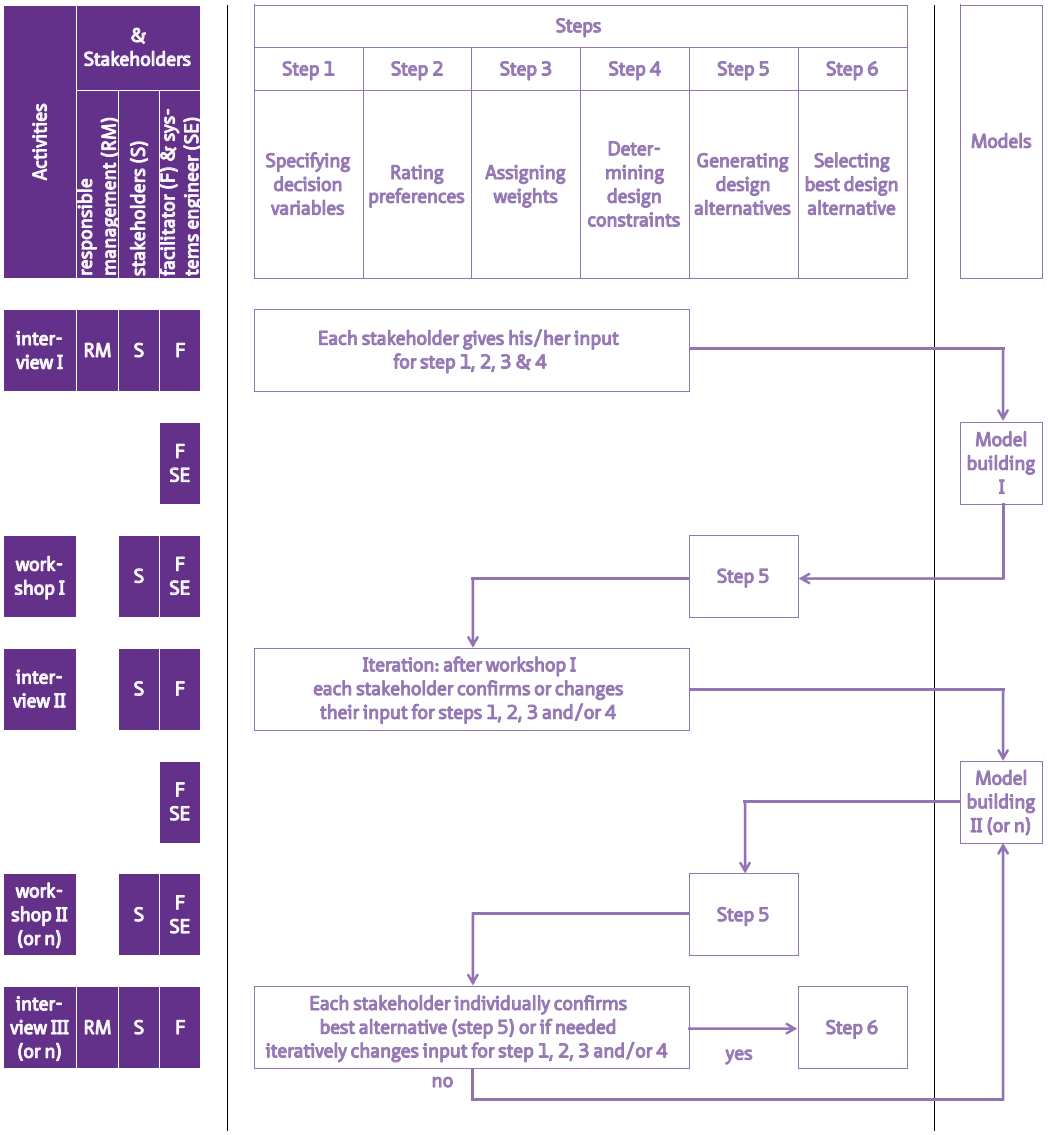


FIG. 6.2 Flowchart of PAS; emphasis on stakeholders & activities Note adapted Arkesteijn et al., 2017, p. 248

TOC

6.1 Pilot study 1: TU Delft's food facilities

This paragraph focuses on the interfaces the stakeholders had available in the pilot study. In chapter 5, based on Arkesteijn et al. (2017) the results of the pilot study have been presented. This means that in this paragraph some explanations are based on this paper and chapter 5.

6.1.1 Interfaces to design alternatives (step 5)

The main objective in the workshop for step 5 (designing alternatives) is to maximize the overall preference score. In this pilot the stakeholders designed the alternatives. The stakeholders in this pilot have been able to design an alternative with an *overall preference score* of 96 as we have seen in paragraph 5.1.6.

The stakeholders have four design interfaces available to work with and these will be discussed subsequently. The first interface is the primary design interface, showing the map of the TU Delft with all the food facilities. The second interface shows detailed information per food facility and enables the stakeholders to select interventions for this food facility. Selecting interventions changes the first interface, as will be shown. The third part of the interface is a detailed table the stakeholders can use when selecting interventions. The fourth interface is an input interface that shows all preference curves for each criterion, enriched with design information. Besides the main design interfaces the stakeholders received three additional design tools, which they could use in their design process. In each part, the interface will be described and a reflection will be given whether or not the interface has been used during the workshops.

Main design interface

The main design interface is displayed in **Figure 6.3**. The model's main interface is the map of the TU Delft showing the current situation of the portfolio food facilities, consisting of 11 restaurants and 3 coffee corners with an *overall preference score* of 44 (out of 100).

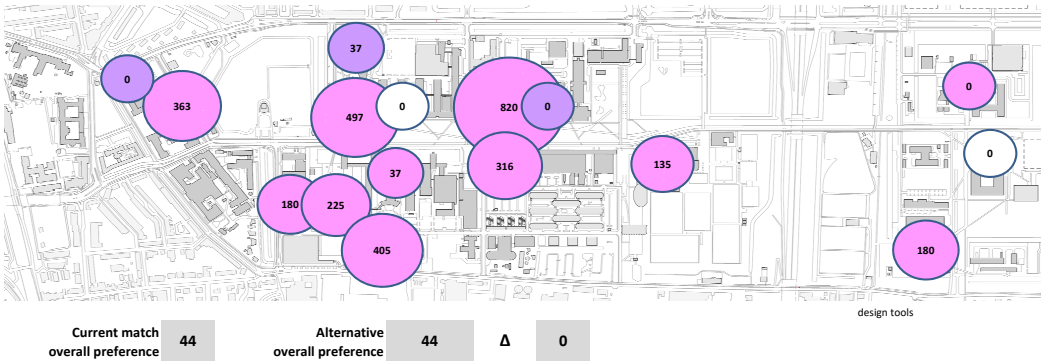


FIG. 6.3 Main design interface Note from Arkesteijn et al., 2017, p. 250

This color of the circles indicated the type of facility; purple indicates coffee corners and pink restaurants either for lunch and/or dinner, with or without coffee corner. The size of the facility, expressed as amount of seats, is mentioned in the circle and the size of the circle represents this.

In the workshops the stakeholders could select each food facility (by clicking on the circle) and press the button 'show location data' which gives them second interface. With the button 'show location', it is possible to return to the map. When a certain intervention is chosen, the overall preference score for this design alternative is shown as well as its add value (indicated with the triangle). After the stakeholders had chosen a set of interventions (see 2nd interface) for the food facilities of their choosing, they generated a design alternative (see **Figure 6.4**). They interactively saw the overall preference score for this design alternative during this design process, as well as the difference in preference score between the designed alternative and the current (zero) alternative. They did not only see the overall preference score but were also able to see the preference scores for each specific variable (see third interface). The decision makers generated several design alternatives in order to search for the highest possible overall preference.

This interface was most used during the workshops.

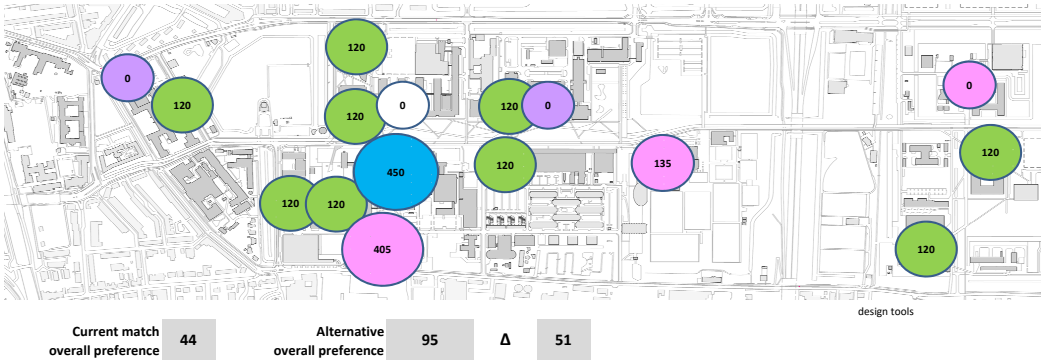


FIG. 6.4 Main design interface displaying the chosen alternative Note from Arkesteijn et al., 2017, p. 255

Intervention interface

The intervention interface is a dialog window which appears after a certain location is selected. In this interface several benchmark data for this facility (see **Figure 6.5 a**) is displayed. The benchmark data for instance shows administrative information, like the building number, but also amount of meter per user and technical state. It contains a pull down menu which enables them to select an intervention for this specific facility (see **Figure 6.5 b**).

In this particular case the following types of interventions are identified:

1. Refrain from action;
2. Remove the food facility;
3. Convert the existing food facility to new concept *middle, large* or *faculty club*;
4. Create a new concept *middle, large* or *faculty club*;
5. Upgrade the existing food facility (add power outlets).

The new concept *middle* is a food facility exclusively intended for lunch, while the new concept *large* is a food facility for lunch and dinner. It is good to note that, during the second workshop, the meaning of the concept *middle* changed. At first, in the concept *middle* cold only lunches would be served, while later the FMRE department partly shifted this into serving both cold and warm lunches. This means that the concept *middle* was not clear enough, and that is why in paragraph 5.1.6 the final alternative was accepted under the condition that concept *middle* would include warm meals as well. Because the new concepts are different from the current

TOC

food facilities, they have been given a different name. When a certain intervention is chosen, the color of the food facility immediately changes to give visual feedback about the type of facility. When the food facility is removed (intervention 2), the color becomes white, when a food facility is converted (intervention 3) it becomes green, and when a new concept is added it becomes blue. In the pull down menu for each food facility, only the feasible interventions were shown.

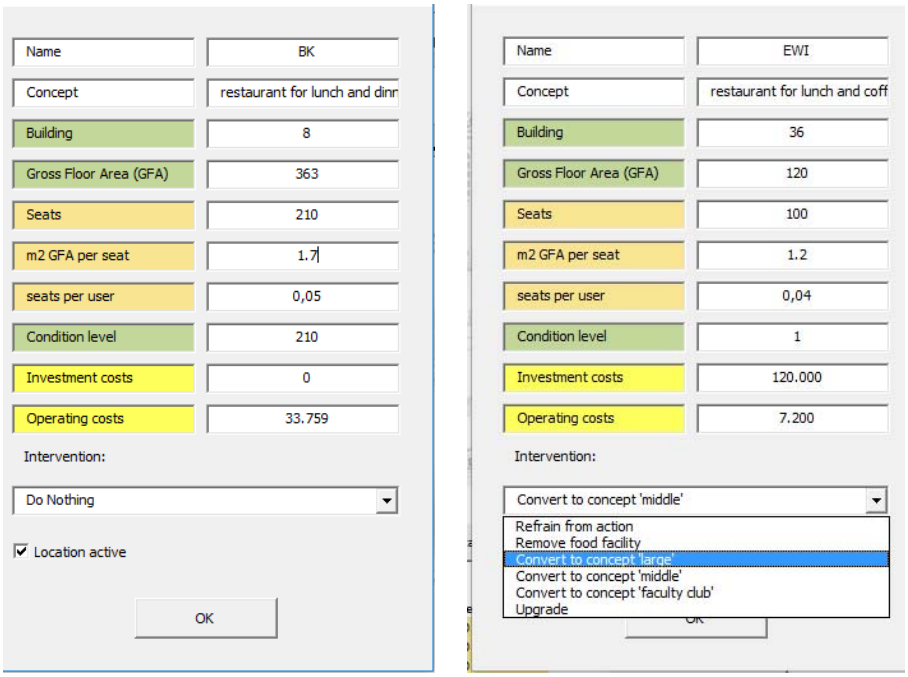


FIG. 6.5 Intervention interface (a) on the left without pull down menu and (b) on the right with pull down menu open

In a presentation the stakeholders were informed about *how* exactly the interventions would influence the preference scores. A new or converted food facility *middle* would have 100 places and 120 m^2 g.f.a., while a food facility *large* would have 300 places and 450 m^2 g.f.a. The decision makers were informed about the values each decision variable would receive when a certain intervention was chosen. An intervention of a food facility to concept *middle* and *large* means: the facility is located on the ground floor near the main entrance, with one door in between the main entrance and the facility, 1 minute average walking time from entrance to the facility, 40% of the places have sufficient acoustics and a preference score of 100 for coziness and ambience.

TOC

The investment costs of a new facility *large* is 1500 euro per g.f.a. and 90 euro per g.f.a. operating expenses and for a new facility *middle* or *faculty club* respectively 1200 euro per g.f.a. and 72 euro per g.f.a. A conversion towards concept *large* or *middle* has investment costs of 1000 euro per g.f.a. and 60 euro per g.f.a. operating expenses.

Interface with design information per stakeholder

Below, the two interfaces are shown with detailed design information. This detailed information is directly linked to each of the specific stakeholders. In **Figure 6.6** design information per stakeholder specifies each of the criteria separately and in **Figure 6.7** design information per stakeholder about their constraint(s) is given. This design information gives the stakeholders guidance (which intervention to select) and shows them the changes in preference score as a result of a (set of) interventions.

The following information is presented in the abovementioned figure.

- In the column weighted score: the overall preference score of the designed alternative is given based on the preferences (curves), stakeholder weights;
- Max. score: indicates the score that an alternative can maximally receive for a specific stakeholder;
- Delta: indicates the amount preference points that another alternative be can earn;
- Value: this is the (physical) value that the designed alternative scores. This value is converted to preference score via the curves;
- Unit: this is the unit in which the value is expressed;
- Score this is the preference score of the designed alternative. This score is converted from the value via the curves;
- Weight: this is the weight that a specific stakeholder gives to his/her criteria.

During the workshops the systems engineers observed that the stakeholders did not use all of the information that was provided in **Figure 6.6**. The column 'delta' was most used as guidance for opportunities to raise the overall preference score. This delta showed the stakeholder which criterion had the lowest preference score and therefore, also could be improved most. The criterion per stakeholder that had the most potential to add value is marked[53]. In the design process, this information guides the stakeholders to appropriate interventions.

53 The model that was used in the workshops with the stakeholders was interactive, which means that the decision variable with the highest delta per stakeholder differed during the design process. The marked cells therefore are only added in this figure.

	stakeholders	design variabeles	weighted score	max. score	delta	value	unit	score	weight
	Faculty secretary	Maximum walking time from a faculty building to a food fac	15	35	20	7	min	42	35%
		Maximum walking time from a faculty building to a food fac	0	5	5	673.263	min	0	5%
		Percentage of places in all food facilities which can be used	4	20	16	11	%	22	20%
		Capaciteit informele plekken	0	0	0	1.300	places	0	0%
		Percentage of places in the facilities having sufficient acoust	4	20	16	4	%	22	20%
		Average preference rating on ambience for the food facilitie	12	20	8	62	-	60	20%
	Student council	Average vertical location of food facility [floors]	11	20	9	0,54	floors	57	20%
		Amount of doors between outside and the food facility [doc	6	10	4	1,54	doors	58	10%
		Average walking time from an entrance to a food facility [m	15	15	0	0	min	100	15%
		Percentage of places in all food facilities which can be used	0	15	15	11	%	3	15%
		Maximum walking time from a faculty building to a food fac	0	30	30	7	min	0	30%
		Maximum walking time from a faculty building to a food fac	0	10	10	673.263	min	0	10%
	Works council	Maximum walking time from a faculty building to a food fac	0	10	10	7	min	0	10%
		Maximum walking time from a faculty building to a food fac	0	25	25	673.263	min	0	25%
		Percentage of food facilities labelled diverse [%]	17	25	8	69	%	69	25%
		Average preference rating on coziness for the food facilities	19	40	21	48	-	48	40%
	Social innov.	Average preference rating on find-ability of the food facilitie	37	50	13	74	-	74	50%
		Percentage of places in all food facilities which can be used	15	50	35	11	%	29	50%

FIG. 6.6 Design information per stakeholder and per design variable

In Figure 6.7 the design information per stakeholder per constraints is given. If a certain constraint was not met this is indicated in this figure (constraint turns red).

Constraints				
Stakeholders		Decision variables	value	unit
	CvB	Accessibility restaurant concept dinner	100	%
		Accessibility restaurant concept lunch	100	%
		Accessibility concept fc	100	%
		User satisfaction	98	-
	Controller	Investment costs	1.850.000	€
		Operating costs	93.240	€/jr

FIG. 6.7 Design information per stakeholder and per design variable

This figure was rarely used during the workshop by the stakeholders. The facilitator and system engineer were the ones that checked this information but only when an alternative was designed that was very promising.

Input interfaces

In the model each of the stakeholders had their own tab where all information as collected in step 1 to 4 was displayed (see Figure 6.9). The visualization of the preference curve was enriched during the workshops by adding two points on the

curves, as can be seen in Figure 6.8. The preference score for the current situation is indicated with a green triangle and the alternative with a red square. In this particular example the walking distance was reduced from 4 to 2 minutes, which corresponds with a preference score of 60 for the students.

In the workshops the stakeholders did not go back to their input screen to look at the position of the current and future situation.

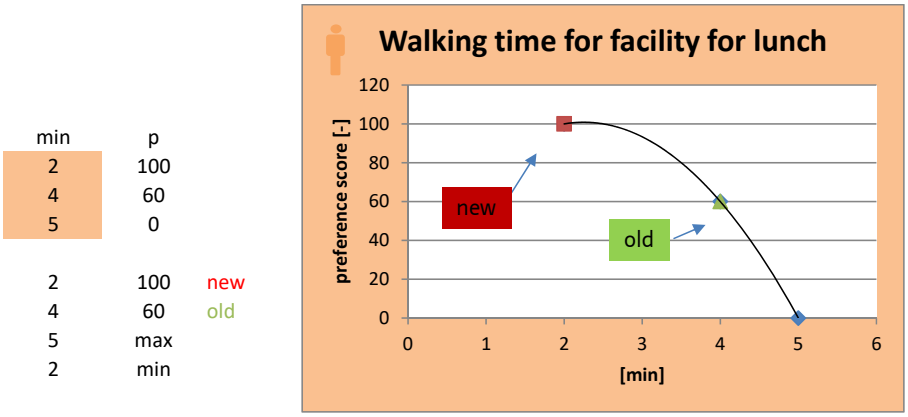


FIG. 6.8 Enriched input interface

PAS interfaces and DAS

In this first pilot, the interfaces occasionally give an explicit connection to DAS. In this case the visualization of DAS by (Den Heijer, 2011) is in the bottom left corner. In the overview per stakeholder (Figure 6.9), DAS was shown and it was indicated that in that particular interface the first task needed to be performed (assessing the current portfolio). In the main interface the heading refers to DAS indicating 'Task 1 and 3: current match and generating future models (see Figure 6.3 and Figure 6.4).

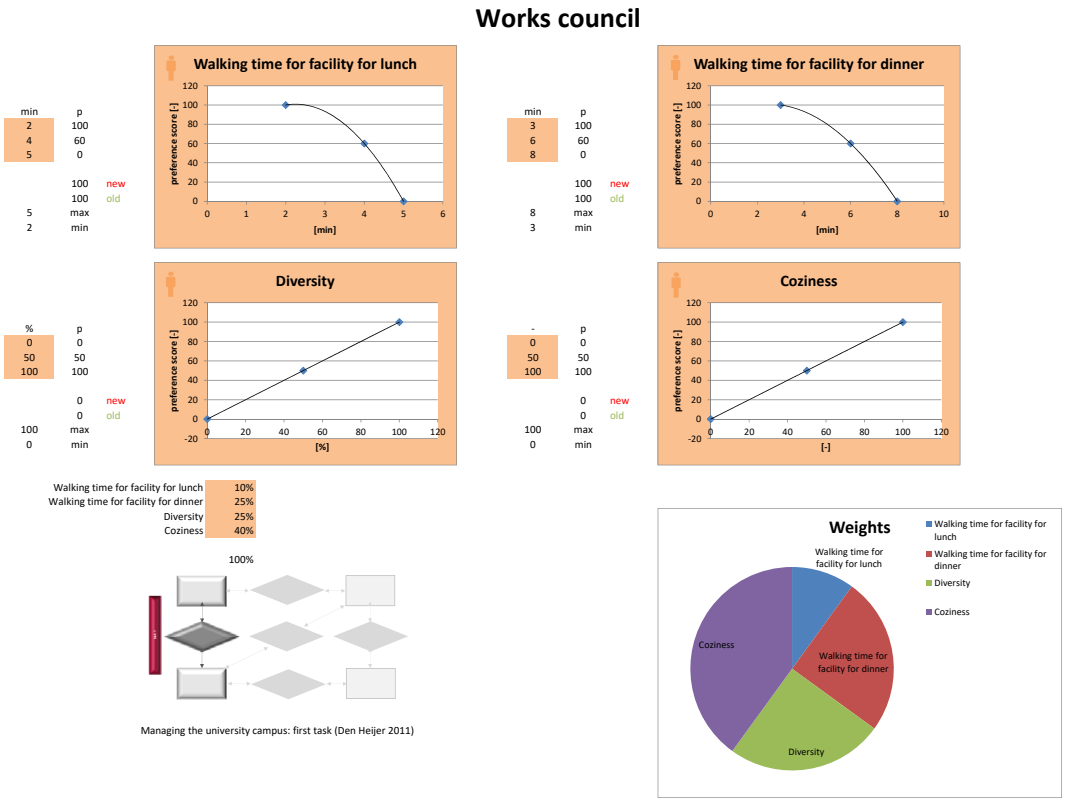


FIG. 6.9 Input interface with overview per stakeholder of step 1 to 3

Additional tools

In the workshops three different additional tools were available:

1. A design tool that displayed whether or not food facilities were available within the desired walking distance;
2. A benchmark of the current food facilities;
3. A reference model to support stakeholders to select relevant criteria given their objectives.

It turned out that these design tools were not or hardly used by the stakeholders therefore, they are displayed in appendix E.

TOC

6.1.2 Workshops to design alternatives (step 5)

The two workshops had different objectives, as explained in paragraph 4.4. In this pilot, the stakeholders were divided into two smaller groups to design alternatives from the perspective of only one of the stakeholders at the time. Each group was assisted by a facilitator or system engineer who operated the computer model. The assignment objective of this workshop was to familiarize the stakeholders with (a) the model itself, (b) whether the systems engineer had interpreted their input from the first steps correctly, (c) the model's performance and its reliability, (d) the criteria other stakeholders listed and especially (e) the effects the interventions had on their own criteria. The feedback during the session is used by the system engineer to improve the model in case of misinterpretations, and by the stakeholders in their second interview. In this interview the insights from this workshop are used to change their individual input, if needed. In this session many alternatives were made designed?.

In each of the workshops each stakeholder received a print out of the slides and a log containing their own information.

In the second workshop the stakeholders received two assignments. For the first, the stakeholders were divided into two groups and were asked to design an alternative with the highest overall preference score. In this workshop each group was assisted by a facilitator or system engineer (see **Figure 6.10**). For the second, the stakeholders compared the results of the two groups, and together made one more iteration to design the alternative with the highest overall preference score that all of them agreed upon. In **Table 6.1** an overview of these alternatives are presented and below the alternatives are presented **Figure 6.11**.

FIG. 6.10 Impression second workshop

TABLE 6.1 Best alternatives as designed in the second workshop

Alternative	Overall preference score	Investment costs	Capacity
Current portfolio food facilities	43	-	3.491
Alternative 1 Group 1	96	2.282.000	2.914
Alternative 2 Group 2	93	2.215.000	2.226
Alternative 3 Entire group	95	1.850.000	2.070

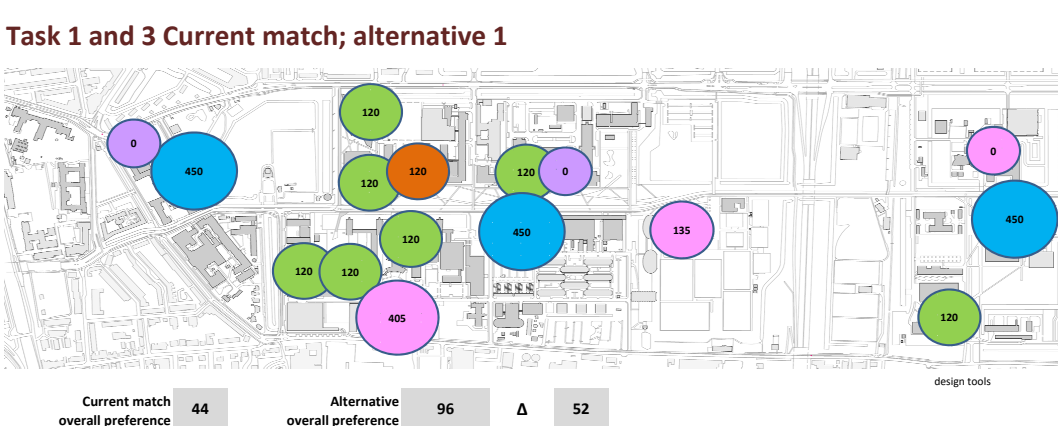


FIG. 6.11 Two alternative designs (alternative 1 on top, alternative 2 at the bottom)

6.1.3 Iterating between alternatives (step 5) and requirements (steps 1 to 4)[54]

The participants were required to design alternatives in step 5. In the workshops, the starting point was the current portfolio ... with the overall performance score based on the weighted sum of all the preference scores. The objective was to iteratively design an alternative with the highest possible overall preference score by modifying both the real estate objects in the portfolio and, if necessary, alter the criteria, curves, weights or design constraints from step 1 to 4.

54 Paragraph 6.1.3 was published as section 6.2.1 in Arkesteijn et al., (2017, pp. 257-258). The cited text is displayed in purple, added text in black. Figure numbers have been altered to suit the thesis

TOC

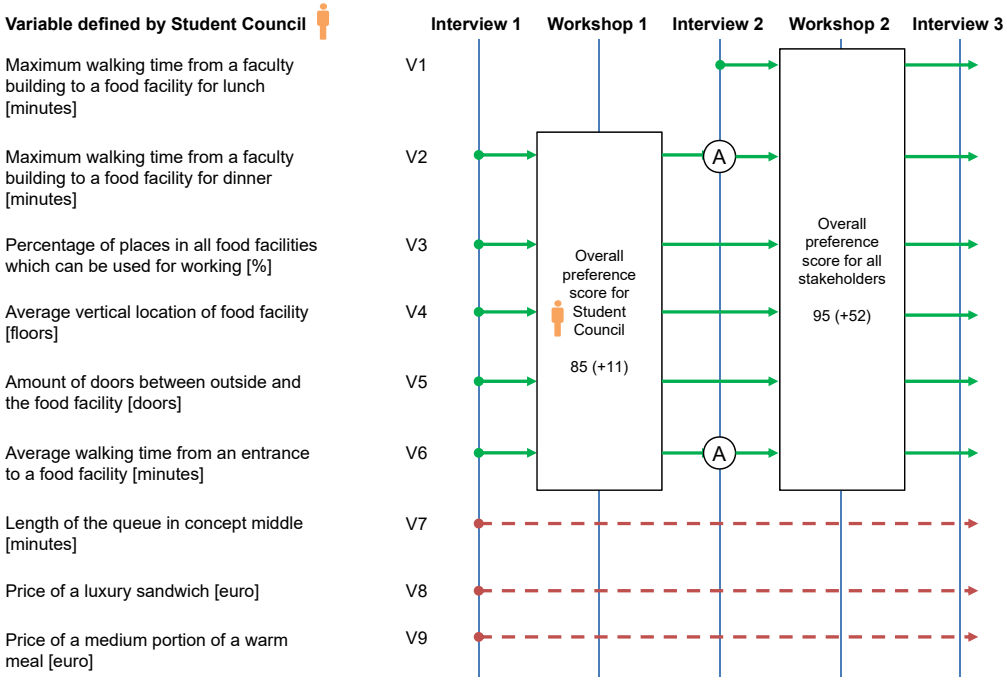


FIG. 6.12 Iteration between interviews (requirements) and workshops (alternatives). A green arrow means that the criterion was incorporated in the model; a red arrow means that it was not incorporated in the model. A box with the letter "A" in it means that a criterion was adjusted in an interview.

In the first workshop the participants were divided into groups and optimized solely based on their own variables, while in the second workshop the stakeholders optimized based on all criteria. **Figure 6.12** shows that iterations were used during the workshop by demonstrating the development of the variables (V) given by the student council. They did not define any design constraints. two variables (V2 and V6) and added a new one (which is called V1). Three variables (not numbered) were mentioned in the first interview but not incorporated in the model. This stakeholder also changed the weights between the variables, both after the first and the second workshop.

What this demonstrates is that the feedback from design helps the users to better understand their input and to improve it if necessary. By doing so, the representation of their preferences in the model better depicts the actual situation. 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.

6.2 Pilot study 2: TU Delft's lecture halls

This paragraph focuses on the interfaces the stakeholders had available in the pilot study. In chapter 5, based on Valks (2013) and Arkesteijn et al. (2015) the results of the pilot study have been presented. Valks (2013) built the model but the interfaces of the model have not been extensively reported on yet[55].

6.2.1 Interfaces to design alternatives (step 5)

The stakeholders have eight design interfaces available to generate alternative real estate portfolios. In this particular pilot, as explained in paragraph 5.2, a combination of preference based design and linear programming was used. The stakeholders expressed their demand similarly as in the first pilot using while linear programming was used to check whether or not a schedule was feasible. This meant that an extra step was necessary in the evaluation of a specific design alternative.

Main design interface

The main design interface is displayed in **Figure 6.13**. The model's main interface is the map of the university showing the current situation of the portfolio lecture halls consisting of 18 lecture halls with an *overall preference score* of 58 (out of 100). On the map, the stakeholder can click on one of the icons representing a lecture hall to select it or he can opt to do a specific intervention in each of the lecture halls. Green lecture halls are currently active, which means that activities are scheduled in them. In lecture halls with a red icon, no activities are currently scheduled.

In this particular case, in contrary to the first pilot, two types of interventions are possible: real estate interventions (on the left hand side) and organizational interventions (on the right hand side; in Dutch 'Ingrepen Proces'). The interventions are explained in paragraph 5.2. The interventions are shown below the map so the stakeholder can apply the interventions directly to the entire portfolio without having to keep navigating through other interfaces. In this way the stakeholder can easily

55 Valks as graduate student joint the project 'Strategic portfolio management' for the Facility Management and Real Estate of the TU Delft. The interfaces were designed jointly and were a continuation of the first pilot. In this pilot, the link between the DAS frame and the steps was made more explicit.

assess the impact of a specific intervention on a portfolio level before specifying and adjusting on an object level.

Below the interventions the overall preference score can be seen. The overall preference score is shown for each stakeholder separately as well as for all stakeholders (grey box). In each box the overall preference score for the current real estate portfolio is given (current match) and the overall preference score for the future real estate portfolio (future match) as well as the added value, indicated as delta. Each rectangle represents a different stakeholder. The stakeholders can see how well the alternative performs on their criteria and also shows the weight they have.

In this interface the stakeholders can also access additional information based on which step of DAS they are performing. All buttons lead to the same interface, but each button shows a different amount of information. In 'task 1 – assessing the current campus' only information with regard to the current situation is displayed. The user can see the current performance of the timetable on a number of indicators and the current performance on each user criterion. In 'task 2 – exploring changing demand' the user can implement a number of timetabling adjustments and see the impact on both the timetable and each user criterion. Both the current and the future match are displayed now. In 'task 3 – generating alternatives' the user can see all the available information.

The effects on the overall preference score are directly fed back at the bottom of the screen. If organizational interventions have been chosen, the stakeholder can again test the allocation and view the effects on the overall preference score and the effects on each criterion design information interface.

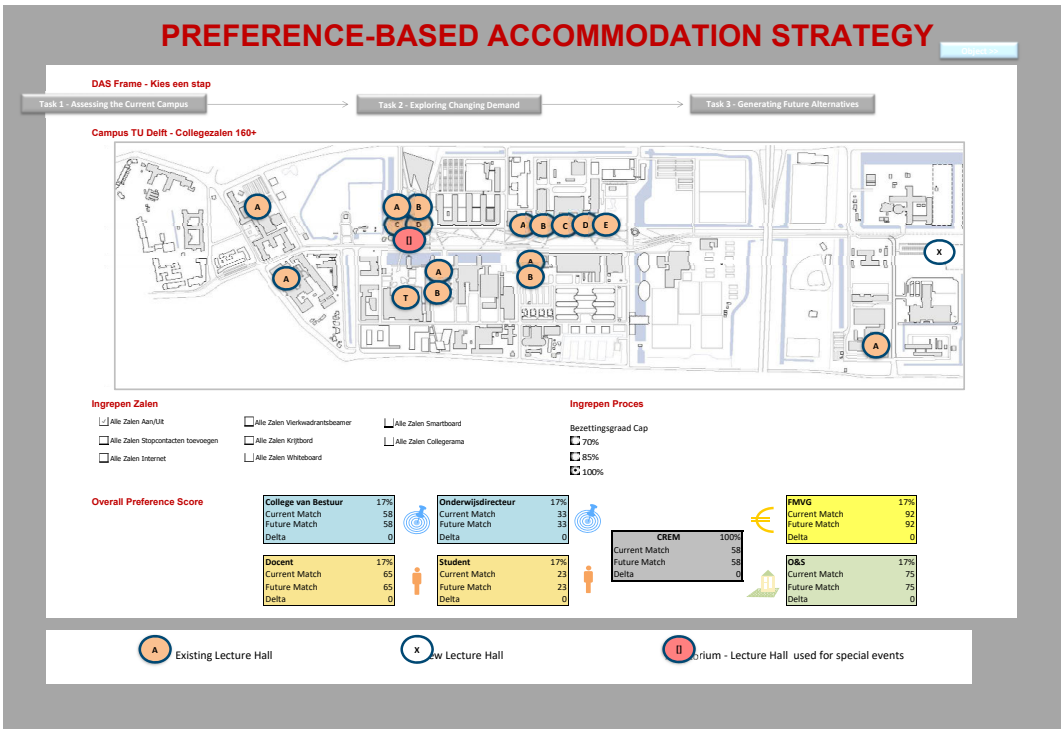


FIG. 6.13 Main design interface

Intervention interfaces for the lecture halls

The intervention interface appears after a certain location is selected in the main interface. In this interface several benchmark data for this facility (see **Figure 6.14**) is displayed. The benchmark data for instance shows administrative information, like the building number, but also amount of meter per user and technical state. It contains a pull down menu which enables them to select an intervention for this specific facility.

TOC

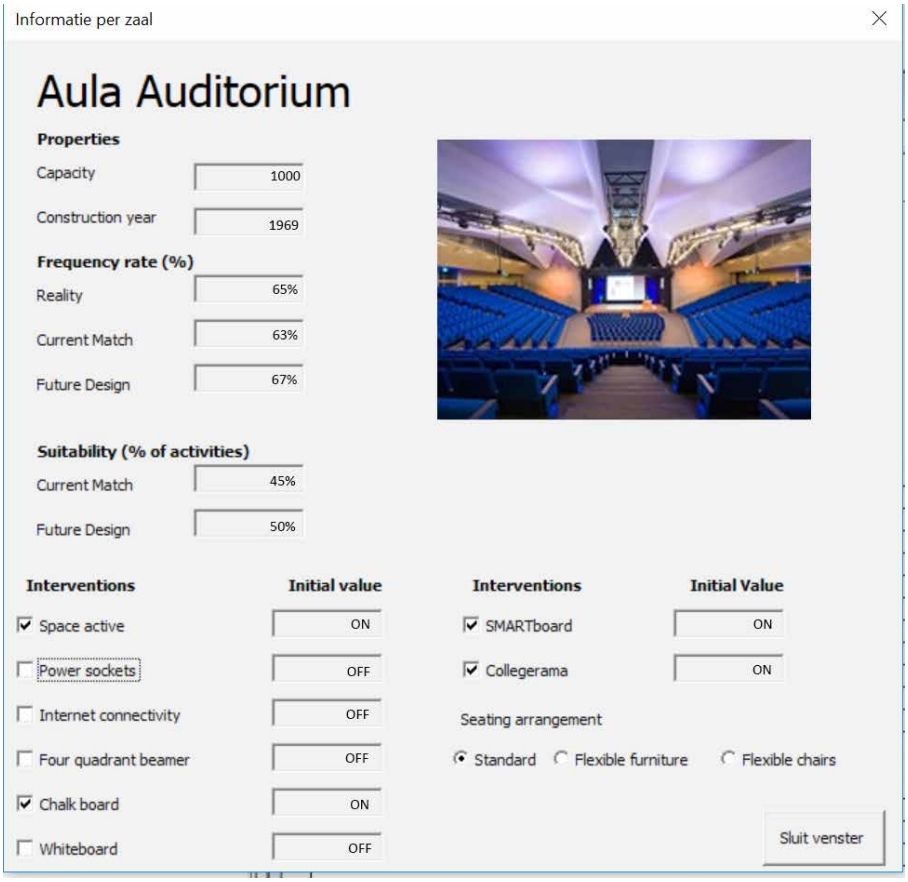


FIG. 6.14 Intervention interface

The following information can be found in **Figure 6.14**:

- Capacity – the amount of seats in the lecture hall;
- Construction year – the year in which the lecture hall was built;
- Frequency rate (%) – the amount of hours that the lecture hall is used as a percentage of the total hours that it is available:
  - Reality – the frequency rate as derived from the university's timetable in the academic year 2012-13;
  - Current match – the frequency rate as calculated in PAS for the current match;
  - Future design – the frequency rate as calculated in PAS for the future design;
- Suitability (%) – the percentage of activities in the schedule for which the lecture hall is suitable; depends on the capacity and facilities in the lecture hall:

TOC

    - Current match – the suitability percentage as calculated in PAS for the current match;
    - Future design – the suitability percentage as calculated in PAS for the future design;
- Interventions – the possible interventions that can be done in a lecture hall. For each intervention the initial value shows what the status in the current match is.
    - Space active – the lecture hall operational and will thus be scheduled for activities;
    - Power sockets – 1 power socket per 2 students will be added to the lecture hall in order to support the use of electronic devices;
    - Internet connectivity – Wi-Fi access points will be added to the lecture hall to increase internet connectivity for students. (This is already present in almost all lecture halls);
    - Four-quadrant beamer – A four-quadrant beamer will be added to the lecture hall. Four-quadrant beamers make a four-screen projection possible. This is an innovation in engineering education that is meant to improve and replace the use of chalk boards;
    - Chalk board – A chalk board will be added to the lecture hall;
    - Whiteboard – Four whiteboards will be added to the lecture hall, which can be used by students to write questions on;
    - SMARTboard – A SMARTboard will be added to the lecture hall. A SMARTboard is an interactive whiteboard on which the teacher can write digitally;
    - Collegerama – A Collegerama set will be added to the lecture hall. Collegerama is a mobile recording apparatus that is used to record lectures;
    - Seating arrangement – The seating arrangement of the lecture hall can be set to flexible chairs, flexible chairs and tables or standard. The selection of a flexible arrangement reduces the capacity of the lecture hall, as these arrangements require more space per m^2.

Doing interventions in the lecture halls serves two purposes. Firstly, it improves the performance of the portfolio with regard to some of the stakeholders' preferences: for example the teaching staff's preference score will increase if more lecture halls include four-quadrant beamers. Secondly, it can improve the suitability of a lecture hall to accommodate an activity (see **Figure 6.19**). For each activity, the course coordinator can specify which criteria a lecture hall must fulfill (e.g. required capacity, presence of a four-quadrant beamer, flexible seating arrangement). If the suitability of lecture halls is improved, it is possible to make a schedule in which the allocation of lecture halls to activities better matches the stakeholder 's preferences. Also, it might be possible to reduce the total amount of lecture halls needed to accommodate all activities.

Intervention interface for the timetable

At the top of the screen the stakeholders can select a step[56] from DAS that they wish to complete: assessing current demand, exploring changing demand or generating future alternatives. When the stakeholders click on one of these steps, a new interface opens. This interface is the same for each of the three steps; however, the information displayed for each of the steps is different. The use of this interface is described for each DAS step.

Step 1: Assessing the current campus

In step 1, the interface serves as an introduction to all the information for the stakeholders. On the first tab (**Figure 6.15**) an explanation is shown of the first DAS step and the CREM model. If a stakeholder wishes to view his criteria, he can navigate to a specific stakeholder by clicking on the icons in the CREM Model. Each stakeholder has an input interface in which their own criteria, curves, weights and design constraints are displayed (**Figure 6.22**). When the stakeholder clicks 'Determine', this interface closes and he returns to the main interface.

In the second tab (**Figure 6.16**), named portfolio level, the stakeholder can view the scope and the current performance of the timetable on a number of indicators: the amount of lecture halls in which activities are scheduled, the amount of activities scheduled, the average frequency, etc.; this is explained further during step 2. Also, the stakeholder can select for which education week a timetable simulation is made. By default this is the first week of the academic year, which is the busiest week (week 1.1). This education week is used to recalculate the current match, after which the stakeholder can proceed to the next DAS task.

In the third tab (**Figure 6.22**), the stakeholder is presented with an overview of the current performance on each stakeholder criterion. Per criterion the current preference score is shown, but also the weights per criterion and the current values of each criterion. Finally, in each tab there is an overview of the current preference scores for each stakeholder on the right.

56 In this pilot in the interfaces and explanations the steps in DAS are sometimes referred to as tasks.

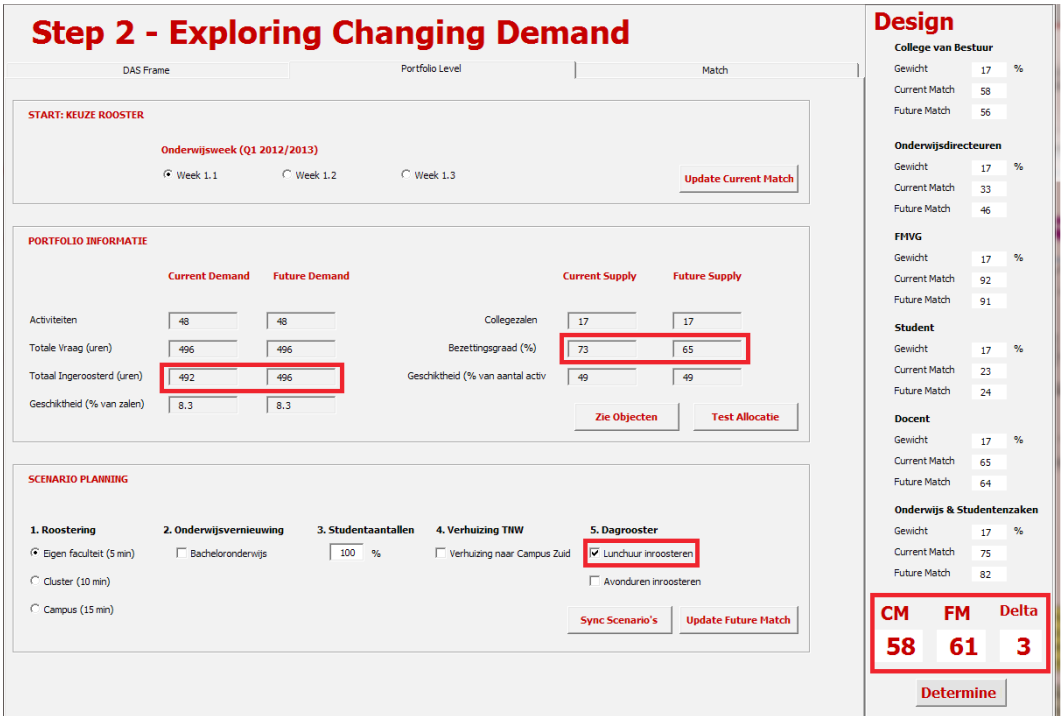


FIG. 6.15 Interface step 1 assessing the current campus; DAS frame

Step 2: Exploring changing demand

If the stakeholders select the second DAS step, 'Exploring changing demand' in the main interface, the timetable interface opens on the second tab, 'portfolio level'. Now additional information is available to the stakeholder. In all parts of the interface, the performance of the future design is shown next to the current match. Because no interventions are done, the performance is exactly the same in all aspects. In the tab 'portfolio level' the stakeholders can explore the changing demand by making amendments to the way activities are scheduled at the university and assessing the impact on a number of indicators (see **Figure 6.16**).

TOC

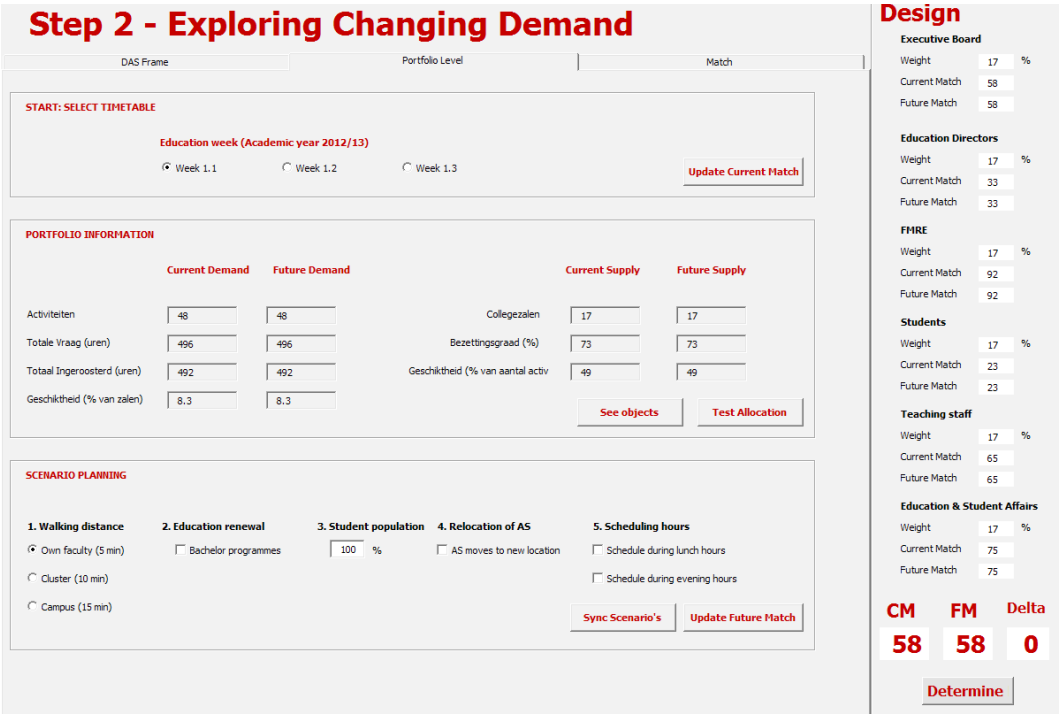


FIG. 6.16 Intervention interface step 2 exploring changing demand; portfolio level showing current situation

The indicators are the following:

- Demand (also referred to as requirements):
  - Activities: the total amount of activities defined. In this model activities are aggregated at the level of educational programs. For example, the first semester of the first year of the Bachelor program of Life Science and Technology is an activity;
  - Total demand (hours): the total amount of hours that is demanded by each activity;
  - Total scheduled (hours): the total amount of hours that is scheduled by the scheduling programmer. Ideally, this amount is equal to the total demand. In order to increase the amount, the amount of active lecture halls needs to be increased or the suitability of the lecture halls needs to be increased;
  - Suitability (amount of lecture halls): the suitability shows how many lecture halls are on average suitable to host an activity. The lower this number is, the more important it is to focus on improving the suitability of lecture halls;

TOC

- Supply (also referred to as (design) alternative):
  - Lecture halls: The total amount of lecture halls in which activities can be scheduled;
  - Frequency rate: The amount of hours in which activities are scheduled as a percentage of the total hours that the lecture halls are available;
  - Suitability (% of activities): the suitability shows the average percentage of activities that are suitable for each lecture hall;
- The user can assess design a scenario with the variables in the 'scenario planning' box, which are:
  - Walking distance: the allocation program determines that an allocation to a lecture hall can or cannot be made based on a predetermined walking distance. The walking distance can be increased (to 10 or 15 minutes) in order to increase the amount of suitable lecture halls for an activity;
  - Education renewal: the education renewal is an ongoing process in which the university expects that different education programs will reduce their amount of large-scale lectures in favor for other types of education, such as project-based education or instructions in classrooms. Applying the education renewal will lead to a 20% reduction of education activities;
  - Student population: the student population is a variable that is subject to change continuously. The stakeholder can adjust the amount of students by filling in a percentage of the current population (for example 120%). This percentage is than applied proportionally over all existing activities;
  - Relocation of Applied Sciences: One of the faculties is in the process of being relocated to a different part of the campus. The stakeholder can move the faculty, and thus all of the activities related to the faculty, to its new location. On the new location there is a fictive lecture hall that can be made active and to which facilities can be added;
  - Scheduling hours: The stakeholder can make it possible to schedule lectures during the lunch hour or in two extra evening hours, aside from the regular scheduling hours. This increases the time to schedule activities in.

In **Figure 6.17**, for instance the stakeholders selected to include the lunch hour in the schedule. By testing the allocation the stakeholder can immediately see what the effects of this scenario are for the portfolio. The amount of scheduled hours has risen from 492 to 496 and the occupation rate of the lecture halls has fallen from 73% to 65%. If he wishes to see how the allocation affects individual activities or lecture halls, he can click the button 'see Objects' to go to an interface that shows the effects of the allocation on each object (**Figure 6.19**). In this example, shows that the *overall preference score* increased from 58 to 61. The stakeholders can see the effects on the overall preference of each stakeholder individually, but not the effects per criteria. This can be seen in the next interface.

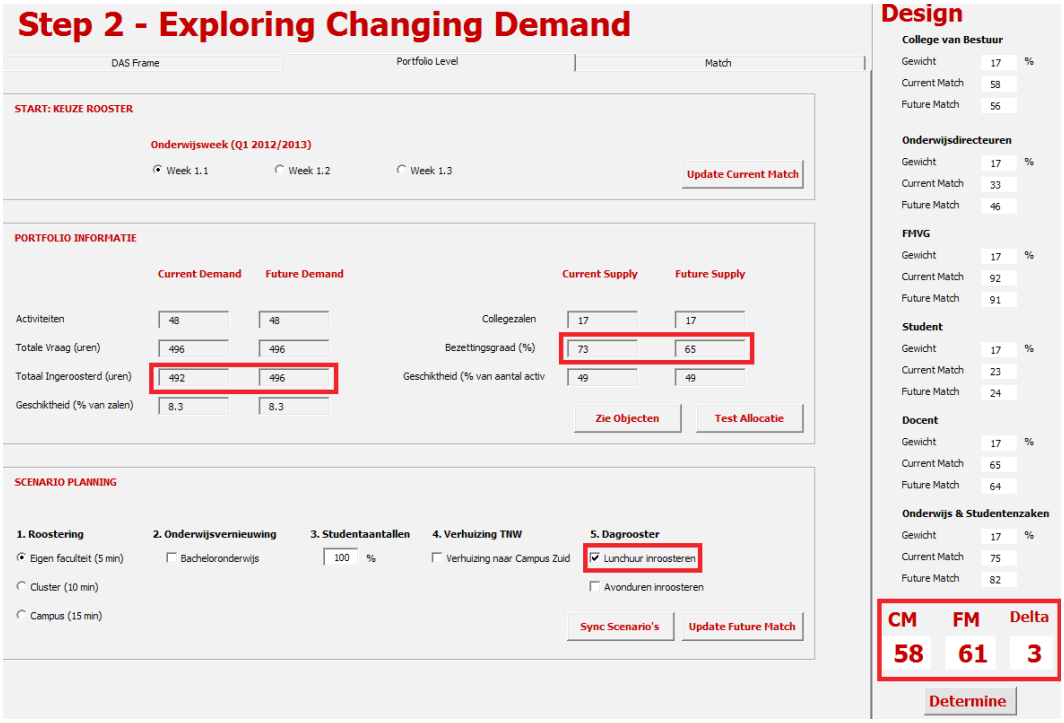


FIG. 6.17 Interface step 2 exploring changing demand; portfolio level

In this pilot, the stakeholders were not informed how exactly each of the interventions would influence the preference scores of the stakeholders. The use of the model would give this insight to them.

After selecting the variables which to adjust, the stakeholders have to (1) press 'sync scenarios' to update the suitability of lecture halls based on the new student numbers (influences capacity of each activity) and walking distance (influences the accessibility of each lecture hall). Then, the stakeholders have to (2) press test allocation to make a new timetable and check if a feasible timetable can be made in this scenario. Finally, the stakeholders have to (3) press update future match to update the values of future match that are displayed in this user interface.

Step 3: Generating future alternatives

In step 3, the timetable interface can be used to check the effect of real estate interventions on the timetable. In the previous step, high-level adjustments have been made to the timetabling process. Aside from doing real estate interventions,

TOC

stakeholders can make some detailed adjustments to activities in the schedule in this step. In step 3, the stakeholders will most likely be using the tab ‘match’ to review the performance on specific criteria. (Figure 6.18). In this interface, the stakeholder can also click on the icon of each stakeholder to view their criteria in order to discover what has caused an increase in the overall preference score.

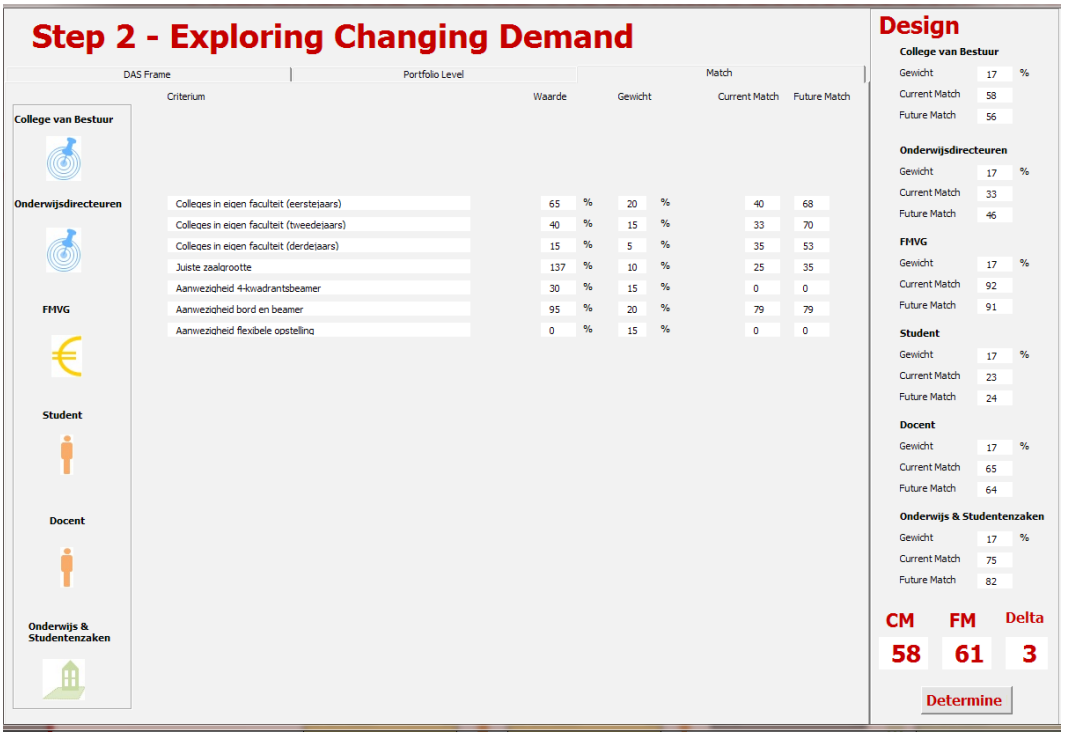


FIG. 6.18 Interface step 2 exploring changing demand; match

Based on the portfolio information, the stakeholder has an indication of where to start, but not specifically where to improve the match between supply and demand. By clicking on ‘see objects’ in the portfolio level tab (See Figure 6.13), the stakeholder navigates to a sheet that shows the status on each of these indicators for each lecture hall and for each activity. In this way, the stakeholder knows for which activity to review the stakeholder requirements, or for which lecture hall interventions need to be done. After making adjustments, the stakeholder can return to this screen and by pressing ‘test allocation’ the stakeholder can review what the improvement on these indicators is.

TOC

Interface object data

In interface object data, the stakeholders can see the effects of the allocation on each object (**Figure 6.19**). This interface is accessed via the 'see objects' button in the timetable interface. On the left side of the screen, the demand is listed: all the activities that are scheduled in the linear programming model. For each activity, the following information is shown for the current match and future design:

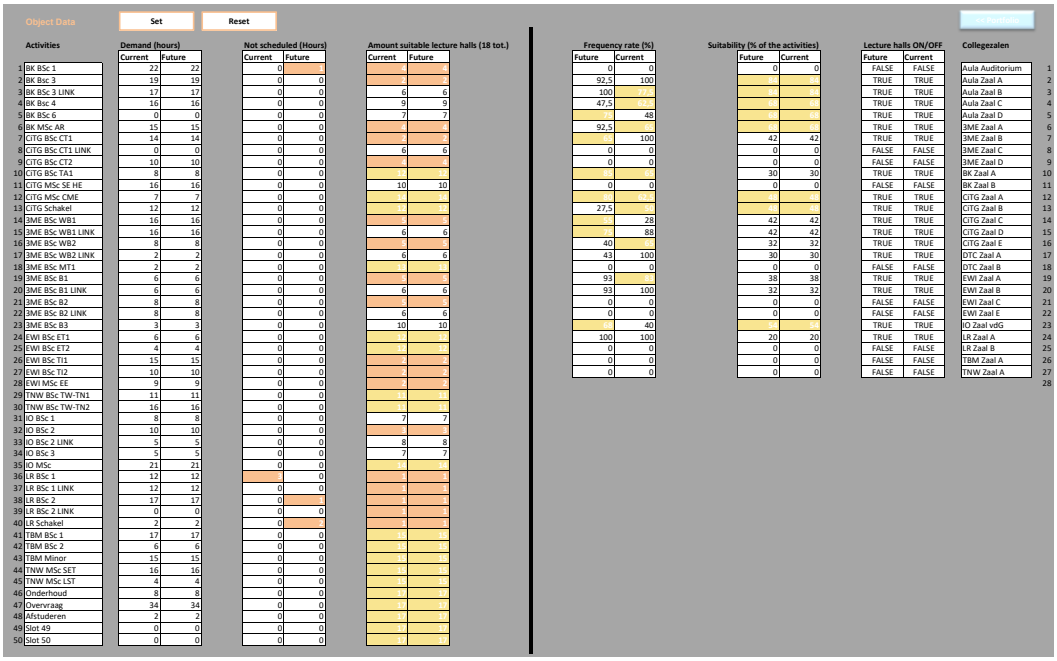
- Demand – the amount of hours scheduled per week;
- Not scheduled - the amount of hours that cannot be scheduled;
- Amount of suitable lecture halls – the amount of lecture halls in which this activity can be scheduled.

If there are hours that are not scheduled in the current match or future design, these are highlighted in red in **Figure 6.17** there is one activity for which this is the case in the current match and 3 in the future design. If there are activities that can only be scheduled in a few lecture halls, they are also highlighted in red; activities that can be scheduled in many lecture halls are marked in green. In **Figure 6.17** there are 18 activities that can only be scheduled in a few lecture halls. If the demands of these activities are adjusted, it will be possible to make a better timetable.

On the right side of the screen, the supply is listed: all the lecture halls in which the linear programming model can schedule activities. For each lecture hall, the following information is shown for the current match and the future design:

- Active – is the lecture hall active in the model and can activities be scheduled;
- Suitability – what percentage of activities can be scheduled in this lecture hall;
- Frequency rate – for which % of the total available time is the lecture hall scheduled.

If the suitability is higher than 45 percent – which means that 45 percent or more of all activities can be scheduled in this lecture hall – it is highlighted in green. If the occupancy rate of a lecture hall is higher than 50 percent, it is also highlighted in green. If interventions are done in a lecture hall with a low suitability percentage, it will increase the amount of activities that can be scheduled there and thus also make a better timetable possible.



Object Data | Set | Reset | Add Participants

	Activities	Demand (hours)		Not scheduled (Hours)		Amount suitable lecture halls (18 tot.)		Frequency rate (%)		Suitability (% of the activities)		Lecture halls ON/OFF		Collegezalen	
		Current	Future	Current	Future	Current	Future	Future	Current	Future	Current	Future	Current		
1	BK BSc 1	22	22	0	0	7	7	0	0	0	0	FALSE	FALSE	Aula Auditorium	1
2	BK Bsc 3	19	19	0	0	7	7	92,5	100	42	42	TRUE	TRUE	Aula Zaal A	2
3	BK BSc 3 LINK	17	17	0	0	6	6	100	77,5	42	42	TRUE	TRUE	Aula Zaal B	3
4	BK Bsc 4	16	16	0	0	9	9	47,5	47,5	42	42	TRUE	TRUE	Aula Zaal C	4
5	BK BSc 6	0	0	0	0	7	7	50	48	42	42	TRUE	TRUE	Aula Zaal D	5
6	BK MSc AR	15	15	0	0	7	7	92,5	95	42	42	TRUE	TRUE	3ME Zaal A	6
7	CiTG BSc CT1	14	14	0	0	7	7	95	100	42	42	TRUE	TRUE	3ME Zaal B	7
8	CiTG BSc CT1 LINK	0	0	0	0	6	6	0	0	0	0	FALSE	FALSE	3ME Zaal C	8
9	CiTG BSc CT2	10	10	0	0	7	7	0	0	0	0	FALSE	FALSE	3ME Zaal D	9
10	CiTG BSc TA1	8	8	0	0	7	7	97,5	97,5	30	30	TRUE	TRUE	BK Zaal A	10
11	CiTG MSc SE HE	16	16	0	0	10	10	0	0	0	0	FALSE	FALSE	BK Zaal B	11
12	CiTG MSc CME	7	7	0	0	7	7	45	45	42	42	TRUE	TRUE	CiTG Zaal A	12
13	CiTG Schakel	12	12	0	0	7	7	27,5	97,5	42	42	TRUE	TRUE	CiTG Zaal B	13
14	3ME BSc WB1	16	16	0	0	7	7	45	28	42	42	TRUE	TRUE	CiTG Zaal C	14
15	3ME BSc WB1 LINK	16	16	0	0	6	6	97,5	88	42	42	TRUE	TRUE	CiTG Zaal D	15
16	3ME BSc WB2	8	8	0	0	7	7	40	97,5	32	32	TRUE	TRUE	CiTG Zaal E	16
17	3ME BSc WB2 LINK	2	2	0	0	6	6	43	100	30	30	TRUE	TRUE	DTC Zaal A	17
18	3ME BSc MT1	2	2	0	0	7	7	0	0	0	0	FALSE	FALSE	DTC Zaal B	18
19	3ME BSc B1	6	6	0	0	7	7	93	95	38	38	TRUE	TRUE	EWI Zaal A	19
20	3ME BSc B1 LINK	6	6	0	0	6	6	93	100	32	32	TRUE	TRUE	EWI Zaal B	20
21	3ME BSc B2	8	8	0	0	7	7	0	0	0	0	FALSE	FALSE	EWI Zaal C	21
22	3ME BSc B2 LINK	8	8	0	0	6	6	0	0	0	0	FALSE	FALSE	EWI Zaal E	22
23	3ME BSc B3	3	3	0	0	10	10	97,5	40	32	32	TRUE	TRUE	IO Zaal vdG	23
24	EWI BSc ET1	6	6	0	0	7	7	100	100	20	20	TRUE	TRUE	LR Zaal A	24
25	EWI BSc ET2	4	4	0	0	7	7	0	0	0	0	FALSE	FALSE	LR Zaal B	25
26	EWI BSc TI1	15	15	0	0	7	7	0	0	0	0	FALSE	FALSE	TBM Zaal A	26
27	EWI BSc TI2	10	10	0	0	7	7	0	0	0	0	FALSE	FALSE	TNW Zaal A	27
28	EWI MSc EE	9	9	0	0	7	7								28
29	TNW BSc TW-TN1	11	11	0	0	7	7								
30	TNW BSc TW-TN2	16	16	0	0	7	7								
31	IO BSc 1	8	8	0	0	7	7								
32	IO BSc 2	10	10	0	0	7	7								
33	IO BSc 2 LINK	5	5	0	0	8	8								
34	IO BSc 3	5	5	0	0	7	7								
35	IO MSc	21	21	0	0	7	7								
36	LR BSc 1	12	12	1	0	7	7								
37	LR BSc 1 LINK	12	12	0	0	7	7								
38	LR BSc 2	17	17	0	1	7	7								
39	LR BSc 2 LINK	0	0	0	0	7	7								
40	LR Schakel	2	2	0	1	7	7								
41	TBM BSc 1	17	17	0	0	7	7								
42	TBM BSc 2	6	6	0	0	7	7								
43	TBM Minor	15	15	0	0	7	7								
44	TNW MSc SET	16	16	0	0	7	7								
45	TNW MSc LST	4	4	0	0	7	7								
46	Onderhoud	8	8	0	0	7	7								
47	Overvraag	34	34	0	0	7	7								
48	Afstuderen	2	2	0	0	7	7								
49	Slot 49	0	0	0	0	7	7								
50	Slot 50	0	0	0	0	7	7								

FIG. 6.19 Object Data

Interface with design information per stakeholder

Below the main interface two tables are shown with detailed information similar to the tables that were available in the first pilot study. This detailed information is directly linked to each of the specific stakeholders. In **Figure 6.20** design information per stakeholder for each of the criteria is shown separately and in **Figure 6.21** design information per stakeholder about each of their constraints is given.

The design information per stakeholder and criterion gives the stakeholders guidance (which intervention to select) and shows them the changes in preference score as a result of a (set of) interventions. All stakeholders have their own section. During the workshops the systems engineers observed that the stakeholders did not use all of the information that was provided in the table. As in the first pilot, the column 'delta' was most used as guidance for opportunities to raise the overall preference score.

Decision maker	Decision variable	Weighted score	Maximum score	Delta	Value	Unit	Score	Weight
Executive Board	1 Education in classrooms and project rooms (%)	26	30	4	43	%	87	30%
	2 Student satisfaction (%)	0	30	30	23	%	0	30%
	3 Teacher satisfaction (%)	11	20	9	65	%	57	20%
	4 Occupancy rate (%)	20	20	0	73	%	100	20%
		58	**100**	**43**				
Education directors	5 First year students: lectures in own faculty	8	20	12	47	%	40	20%
	6 Second year students: lectures in own faculty (%)	5	15	10	28	%	33	15%
	7 Third year students: lectures in own faculty	2	5	3	13	%	35	5%
	8 Ratio between students and lecture hall capacity	3	10	8	144	capacity / group size	25	10%
	9 Availability of four-quadrant beamer (%)	0	15	15	29	%	0	15%
	10 Availability of blackboard and beamer (%)	16	20	4	94	%	79	20%
	11 Availability of flexible chairs (%)	0	15	15	0	%	0	15%
	12 Education in small classrooms (%)	-	-	-	-	-	-	-
		33	**100**	**67**				
Student Council	13 Amount of lectures recorded (Collegerama) (%)	0	15	15	96	%	93	15%
	14 Amount of lectures in the evening	20	20	0	0	%	100	20%
	15 Amount of movements between buildings	10	15	5	0,3	times	71	15%
	16 Lectures in own faculty (%)	0	30	30	42	%	0	30%
	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 (%)	1	10	9	71	%	56	10%
	21 Flexible lecture halls (%)	0	10	10	18	%	69	10%
		31	**100**	**69**				
Teacher	22 Standard equipment (%)	18	20	2	100	%	100	20%
	23 Blackboards/whiteboards (%)	13	20	7	100	%	100	20%
	24 Flexible chairs (%)	0	20	20	18	%	0	20%
	25 Walking distance for students (minutes)	20	20	0	5	%	95	20%
	26 Amount of lectures recorded (Collegerama) (%)	14	20	6	96	%	98	20%
	27 On-site assistance (minutes)							
	28 Assistance in transport of teaching materials (hours)							
	29 Reservation of parking spots (%)							
		65	**100**	**35**				
E&S Affairs	30 Walking distance for students (minutes)	35	35	0	5	minutes	98	35%
	31 Ratio between students and lecture hall capacity	11	30	19	144	capacity / group size	100	30%
	32 Occupancy rate (%)	13	35	22	63	%	25	35%
	33 Functionality of lecture hall equipment (%)							
		59	**100**	**41**				
FMRE	34 Occupancy rate (%)	30	30	0	73	%	87	30%
	35 Ratio between students and lecture hall capacity	22	30	8	71	group size / capacity	67	30%
	36 Investment costs (€)	0	40	40	596480	€	0	40%
		52	**100**	**48**				

FIG. 6.20 Design information per stakeholder per criterion

In Figure 6.21 the design information per stakeholder per constraint is given. If a certain constraint was not met this is indicated in this figure (constraint turns red).

Decision maker	Design Constraint
Student Council	1 Two-way interaction with the teacher at all times
	2 The amount of students present cannot exceed the lecture hall capacity
E&S Affairs	3 The DUT must have enough capacity to accommodate all mandatory activities
	4 The maximum amount of scheduled hours per student per day is eight hours
	5 Mandatory courses cannot be scheduled at the same time

FIG. 6.21 Design information per stakeholder per constraint

This figure was rarely used during the workshop by the stakeholders. The facilitator or system engineer were the one that checked this figure but only when an alternative was designed that was very promising.

Input interface

In the model, each of the stakeholders had their input interface where all the information from step 1 to 4 was displayed (see **Figure 6.22**). The visualization of each preference curve was enriched during the workshops by adding two points on the curves similar to the first pilot. In the workshops the stakeholders did not go back to their input screen to look at the position of the current and future situation.

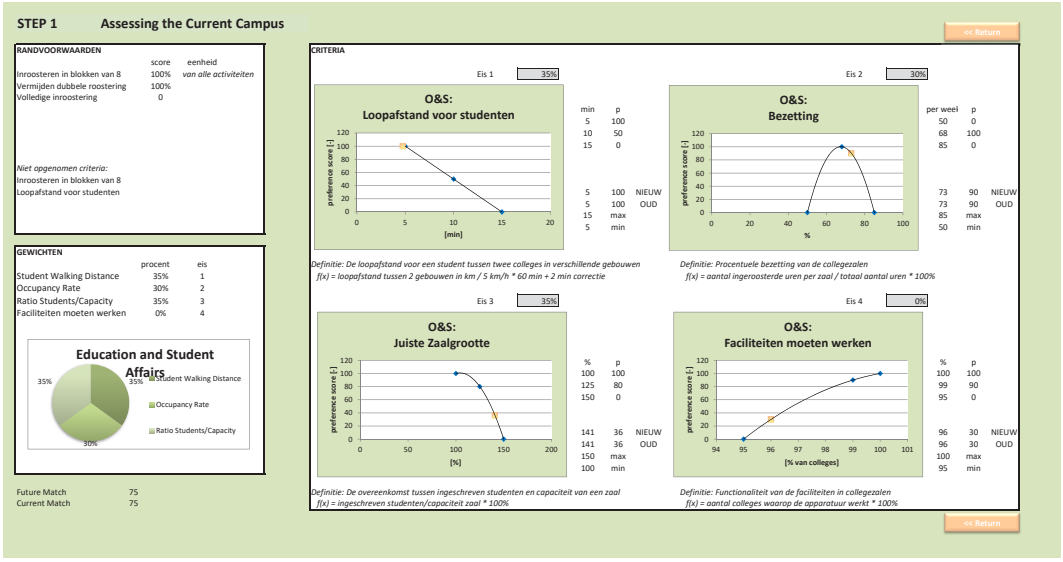


FIG. 6.22 Interface assessing the current campus; overview of requirements (step 1 to 4)

TOC

PAS interfaces and DAS frame

In the second pilot study the relationship between PAS and DAS has been made more explicit and clear. In the main interface (Figure 6.13) the three of the four tasks that can be done in PAS are displayed. In this model the tasks are referred to as steps. Later on the interfaces are explained based on these three steps. Many interfaces show both the first and second step. An overview of the links between PAS and DAS is shown in Table 6.2.

TABLE 6.2 Overview links PAS and DAS

Step/Task	Figures
1 assessing the current campus	6.13, 6.15, 6.20 and 6.22
2 exploring changing demand	6.16, 6.17 and 6.18
3 generating future models	6.13, 6.14, 6.18, 6.19, 6.20 and 6.22

Additional tools

In this pilot study no additional tools have been used.

6.2.2 Workshops to design alternatives (step 5)

The two workshops had different objectives, but in each pilot the workshops were approached slightly different. The first workshop for this pilot was an individual workshop. The objective in this workshop was to design an alternative with the highest overall preference for a particular stakeholder. (Impression in Figure 6.23)

The second pilot was a group workshop and consisted of three assignments. For the first assignment the stakeholders were split into group a and group b. Group a was assigned to design an alternative with the highest overall preference using the interventions in the lecture halls. Groups b on the other hand, could make use of the interventions in the scheduling process. In the second assignment the groups were joined into one group and asked to design an alternative with the highest overall preference, using all interventions. The third assignment was to design an alternative with the highest overall preference for different futures.

FIG. 6.23 Impression second workshop first assignment Note from Valks, 2013, p. 65

Group 1 designed an alternative by doing interventions in the timetable. A minor increase in the overall preference score could be reached by these interventions, most notably on the criteria of the directors of education. Group 2 designed an alternative by doing interventions in the lecture halls. By adding a number of amenities they managed to reach an overall preference score of 65. Especially the teachers and students' preference increased in this alternative, whilst the preference of FMRE decreased due to high intervention costs. These alternatives were put together and with some minor adjustments the final design alternative was made, with an overall preference score of 69. (Valks, 2013, p. 69) (see **Table 6.3**).

TABLE 6.3 Best alternatives as designed in the second workshop

Alternative	Overall preference score	Type of interventions	Solution space for the schedule
Current portfolio lecture halls	58	None	6.830
Alternative 1 Group 1	62	Lecture hall interventions	6.897
Alternative 2 Group 2	68	Timetabling & lecture hall interventions	11.295
Alternative 3 Entire group	69	Timetabling and lecture hall interventions	12.639

6.2.3 Iterating between alternatives (step 5) and requirements (steps 1 to 4)[57]

At the outset of the project, our expectation was that this process of design would help the participants to better understand the relationship between the design alternatives and their requirements. This was confirmed in the evaluation: the participants indicated that whilst the method of determining preferences is easy, accurately determining which preference is related to a certain value is not. Assigning preference scores to values of e.g. the occupancy rate can be arbitrary at first.

By repeating the cycle of determining preferences and making designs a number of times, the participant can see what the effect of the decisions made in the design is, and how those decisions affect the stated preference. In this paragraph, the iteration of the stakeholders between their requirements (i.e. step 1 to 4, also called demand) and the alternative design (i.e. step 5 also called future supply) is shown for the student council.

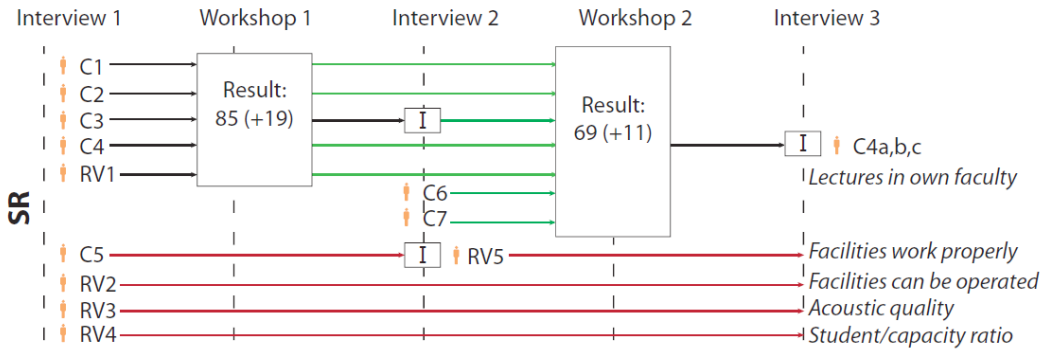


FIG. 6.24 Iteration between requirements and alternatives Note from Arkesteijn et al., 2015, p. 117 SR stands for student council, C stands for criterion, RV for boundary condition

In **Figure 6 24** the development of the criteria (C) and boundary conditions (RV) given by the Student Council (SR) are displayed. After workshop 1, the Student Council participant modified one criterion (C3) and added two new ones

57 Paragraph 6.2.3 was published as section 6.2.1 in Arkesteijn et al., (2014, pp. 116-117). The cited text is displayed in purple, added text in black. Figure numbers have been altered to suit the thesis.

TOC

(C5 and C6). After workshop 2, he modified one criterion (C4) and split it into three separate criteria. In both of these examples the weights between the criteria were also adjusted.

6.3 Pilot study 3: Oracle's office locations

6.3.1 Interfaces to design alternatives (step 5)

The main objective of the stakeholders in the workshop in step 5 'designing alternatives' is to maximize the overall preference score. In this pilot the stakeholders not only designed alternatives themselves. Next, to their own design, an optimization tool was also used to generate alternatives. In this paragraph the design interfaces that have been used by the stakeholders in this pilot will be shown. Note that De Visser (2016) refers to the design interface as GUI which is the abbreviation of Graphical User Interface. In the first main design interface the stakeholders can design alternatives. The second interface shows detailed information per criterion and enables the stakeholders to refer back to their input. In this particular pilot one extra design tool has been created.

This paragraph is based on De Visser (2016, pp. 67, 71-72)[58].

Main design interface[59]

The final GUI is shown in **Figure 6.25** and provides the possibility to design portfolio alternatives quite intuitively by filling out a set of checkboxes. This is done in the design table on the left side, which also provides the location preference score. The selected locations appear in the table in the middle, presenting the current design.

58 The cited or summarized text is displayed in purple, added text in black. Paragraph and figure numbers adjusted to this thesis.

59 The numbers in the main design interface are presented with two decimals, which suggests a certain level of precision. The systems engineer and model expert realize that this could give the wrong signal. The stakeholders have been informed about this.

Above this table, the number of locations selected is shown. Once selecting the button ‘Calc. Preference’, the overall preference score for the design appears in the top right corner. In the table on the right side with the criteria and criteria weights, the average physical values and preference scores per criterion appear for the portfolio design. Below this table, the difference between the preference score for the current portfolio and the alternative design appears.

Moreover, De Visser built some additional features that have been implemented to improve the design process. The possibility to name and save design alternatives makes it possible to get back to previous ideas and build upon them by recalling them in the design screen. Other features are the possibility for the stakeholders to disable the design constraint on the number of locations and to unselect all locations at once. Finally, the visual feedback that is provided by De Visser, in the middle of the design interface, shows whether or not the designed alternative is within the design boundaries (De Visser, 2016, pp. 71-72).

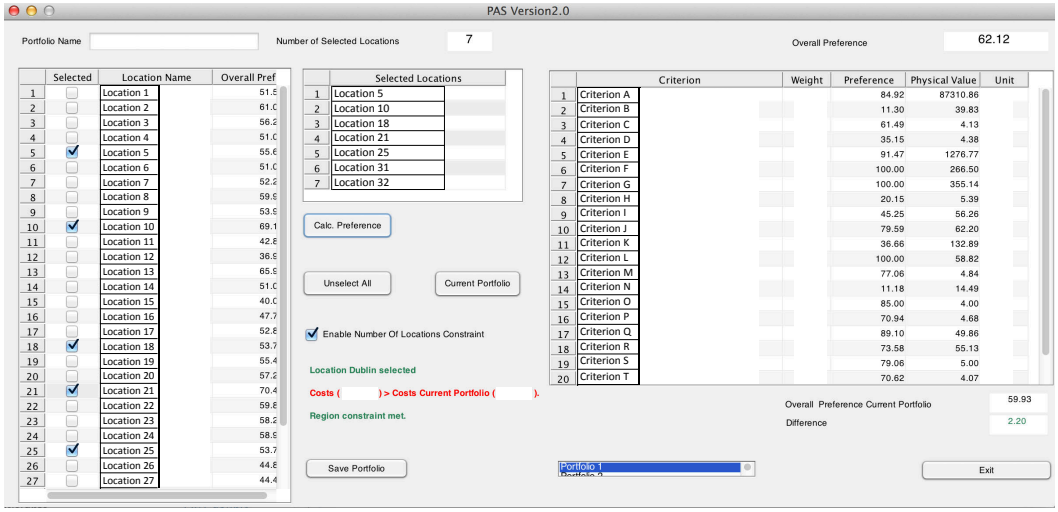


FIG. 6.25 Main design interface Note from De Visser, 2016, p. 71

Input interface

The input interface provides direct feedback to the interviewee with to their input. This interface is similar to the design interfaces in the first and second pilot. This interface has been used during the interviews. As the interviews were held via a conference call connection, the systems engineer shared his screen with the

TOC

interviewee. As this interface was made in MS Excel and not in Matlab[60], it was not possible to give feedback about the portfolio alternatives on the input curves as was done in the first two pilots. This means that this interface was used during the interviews and not during the workshops (De Visser, 2016) (see **Figure 6.26**).

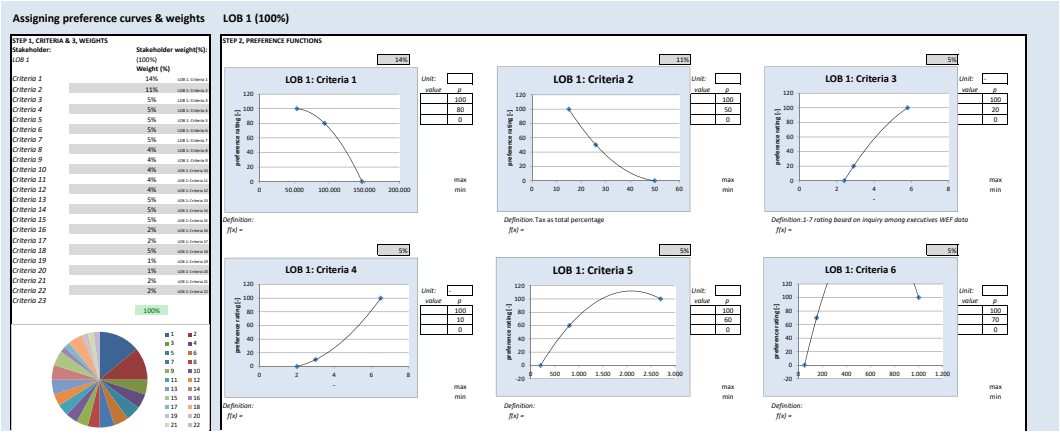


FIG. 6.26 Input interface with overview per stakeholder of step 1 to 3 Note from De Visser, 2016, p. 67

PAS interfaces and DAS

In the third pilot there was no direct link between PAS and DAS.

Additional design tools

One additional design tool was used in the process. Because the physical values and criterion scores for the individual locations were not visible in the main design interface these values were provided separately. These values remained the same during the whole pilot study. The stakeholders used this file during workshops. The system engineer indicated that it is possible that the stakeholders not fully understood this tool, because they did not select the location with the highest overall preference score into their new portfolio. This means that this overview should have been explained more to the stakeholders.

60 Matlab (matrix laboratory) is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. https://en.wikipedia.org/wiki/MATLAB

TOC

6.3.2 Workshops to design alternatives (step 5)[61]

Each workshop started with an introductory presentation by the systems engineer, who was responsible for the model and workshop structure, to refresh the goal of the research project and the workshops and to present the expected outcomes of the workshop. In this presentation also the two elements in the workshops were introduced; designing an optimum location portfolio for LOB 1 [Line of Business] and comparing the rankings from the original study and PAS. The introduction to the first workshop also included an elaborate explanation of the model backside in a visual representation. Each presentation ended with an explanation of the assumptions made in the modeling of the stakeholders' input and an explanation of the design interface. Also the systems engineer indicated that from that point on, the control over the model was in the hands of the users[62].

In the workshops, the users received two design assignments; one with the current portfolio plus one location and one to design a portfolio regardless of the current portfolio. During the first workshop, one of the users correctly observed from the design interface how the overall preference score for a portfolio alternative followed from the preference scores based on the average physical values per criterion. Also it was observed that in order to design the optimum portfolio it would be logical to start with the locations with the highest individual preference score, although these scores were not directly used to arrive at the overall preference score. Another element that stood out in this design process was that one of the users came up with the note that in reality some locations would never be left by the LOB because they needed to cover certain regions. therefore, she thought that these locations should always be included, which resulted at the end of the workshop in an additional constraint, requiring a certain regional coverage. Also the observation was made that designing the portfolio with the highest preference scores, meant that a lot of expensive locations were included. In real life this could not be the case because it would make the portfolio too costly. The users discussed amongst one another that costly locations are not forbidden, but should be compensated with cheaper locations. This resulted in a constraint that determines that the average costs for a portfolio alternative are not allowed to exceed the costs of the current portfolio. The formulated two constraints resulted in three new design constraints because one of them actually incorporated two separate constraints.

61 The cited or summarized text is displayed in purple, added text in black. Paragraph and figure numbers adjusted to this thesis.

62 The term user here refers to 'user' of the model, i.e. workshop participant or involved stakeholder.

In the comparison of rankings in the first workshop, the users were interested to see what the individual effects of using preference curves and new weights are on the ranking. They recognized that the new weights might represent progressive insight in the matter from the LOB's point of view.

In the second workshop, designing portfolio alternatives that did not violate either of the constraints had become somewhat more complex as the users indicated. However, they also noted that it made them more aware of the implications of certain decisions, e.g. regions with only one location. Also the users observed that in the future they might need somewhat more refinement in the location data by means of including the headcount per location in order to optimize the portfolio for costs versus regional 74 coverage, i.e. covering a region with an expensive location, however with low headcount to decrease total costs (De Visser, 2016, pp. 73-74).

6.3.3 Iterating between alternatives (step 5) and requirements (steps 1 to 4)

De Visser (2016, p. 93) also looked at the iterations during the process and displayed them in **Figure 6.27** and reported the following:

The [**Figure 6.27**] ... shows the development of the criteria and design constraints over the course of the pilot study. It shows that in the first interview the stakeholders established a set of criteria and one constraint that led to the resulting preference score in workshop 1. After workshop 1, the users included three extra constraints. This shows that the users gained insight in their input through the design process in the first workshop and were able to adapt it accordingly. This resulted in a better representation of their preferences in the model. However, from the [**Figure 6.27**] it also becomes clear that no iterations were made in the criteria. This can be explained by the fact that this pilot study is conducted with an existing case for which the criteria were already deemed suitable. Finally, the [**Figure 6.27**] shows that the brute force function was indeed able to find a portfolio alternative with a higher preference score than the stakeholders could find in the second workshop.

The evaluation of the ... PAS[63] ... shows that the participative process of design really pays-off in terms of model acceptance and trust in the model and its outcome. One

63 De Visser in his thesis referred to PAS as improved PAS. This is PAS including the use of an optimization tool. For ease of reading in the text of De Visser, it is referred to as PAS in this thesis

of the stakeholders even indicated already before the search algorithm outcomes were available that she would trust them, because she understands how the model works. Eventually, the outcome of the brute force function was indeed accepted by the stakeholders as final result of the pilot study.

In this pilot, as can be seen in the [**Figure 6.27**], the stakeholders did not alter any criteria. It is logical that they did not need the iterations like they did in the first two pilots, because this pilot was a repetition of their own location decision process in which the criteria were already set.

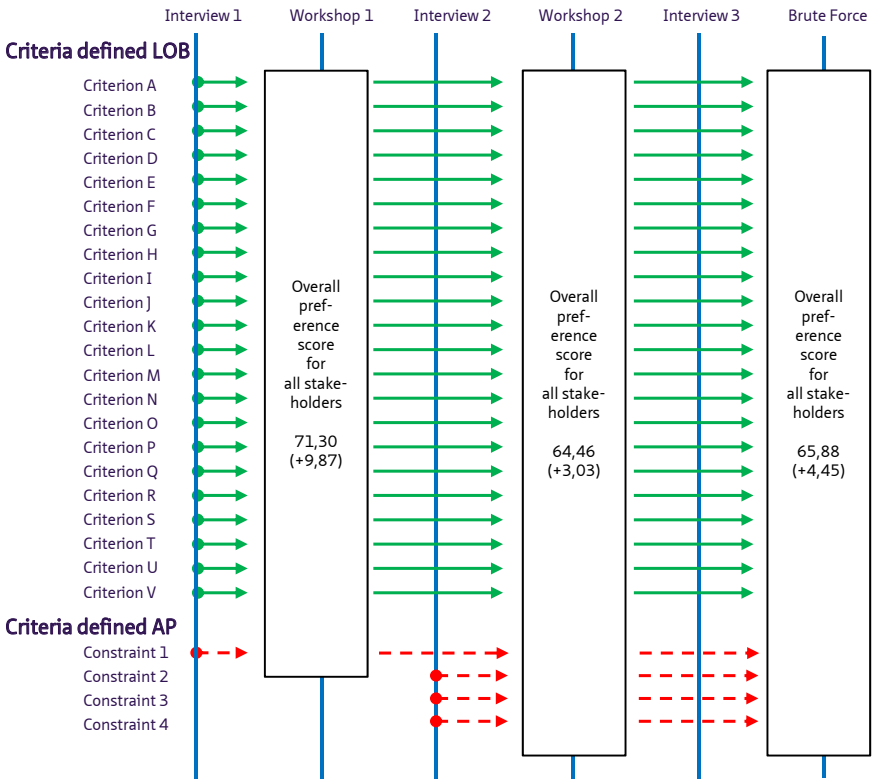


FIG. 6.27 Iteration between requirements and alternatives Note from De Visser, 2016, p. 93

In this pilot has implemented a few improvements, based on the observations and interviews from the first two pilots. These improvements ". . . concern the way in which the users are made familiar with the backside of the system, the evaluation

TOC

of the perceived ease of use and justification of the model outcomes by providing the preference score per criterion. In the evaluation, the users were predominantly positive about these aspects, although for some the explanation of the model back-end could have been more in-depth (De Visser, 2016, p. 93).

6.4 Pilot study comparison and conclusion

The stakeholders in all three pilots have successfully performed the two activities: workshops and interviews. In these activities, all six steps have been performed. By iterating between the steps in the interviews and workshops a number of times, the stakeholders better understood their input and were able to improve it. This means that the representation of their preferences in the model better depicts the actual situation. 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.

In all pilots it has been shown that workshops with all stakeholders produced satisfactory results. The stakeholders were presented with several assignments which helped them design an alternative CRE portfolio with the higher overall preference. Most stakeholders preferred to have two joint workshops instead of one. PAS gives stakeholders the opportunity to determine the amount of workshops and interviews, stopping the iterative process only when all stakeholders accept the result. In the further development of PAS, it is worthwhile to experiment with a (partially) stakeholder operated model.

The amount of the available design interfaces per pilot differed (**Figure 6.28)** as well as the intensity in which the design interfaces were used. In all pilots, the main interface in which alternatives could be designed, was used most. Furthermore, the interface displaying the interventions (if available) was used often. In the second pilot, the preference scores per stakeholder were integrated in the main interface. The interface with the design information per stakeholder and per design variable was used less, and in the first two pilots, was used mainly by the facilitator and system engineer. In the third pilot, this information was integrated in the main interface. In general, the conclusion is that the design interfaces with more condensed display of information were most used.

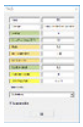
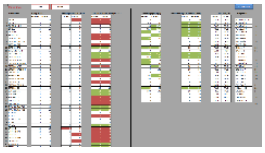
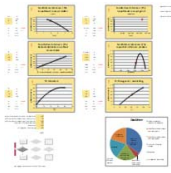
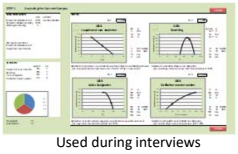
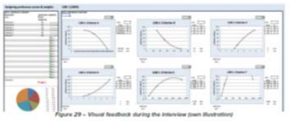
interfaces	Pilot 1 food facilities (TUD)	Pilot 2 lecture halls (TUD)	Pilot 3 office locations (Oracle)
Main design interface	 most used interface & visualization contains information	 most used interface & visualization only shows presence location	 most used integrated interface, lacks portfolio visualization
Intervention interface	used interface 	used interface 	Not present
Interface with design information per stakeholder	Too detailed / less used 	Too detailed / less used 	Not present
Basics of PAS	Not present		Not present
Interface with Object data	Not present		Not present
Input interface	Used during interviews not in workshops 	 Used during interviews not in workshops	 Used during interviews not in workshops

FIG. 6.28 Overview of interfaces

The design interfaces for the pilots differed (see **Figure 6.28**). The first and second pilot were visually more similar for two reasons. First of all, they were part of the same pilot study at the TU Delft and performed and led by the author. Secondly, pilot one and two were created in MS Excel, whereas pilot three was created in Matlab. The models for the first and second pilot, were more visual, while in the first pilot the visualization (size and type of the food facilities) contained most information. The model for the third pilot was less visual but contained more information in the main design interface. In the further development of PAS, it is worthwhile to enhance and experiment with the main design interface in the mathematical model.

The relationship between PAS interfaces and DAS differed per pilot. Whereas, the second pilot study made the most explicit relation between the two, the first pilot did this only briefly. Since some stakeholders at TU Delft were familiar with DAS, it made sense to make an explicit link. In the third pilot the interfaces did not refer to DAS.

The type of information displayed in the main design interfaces differed as well (see **Figure 6.29**). Per pilot, it is displayed which information is given in the main interface, and which information is given in other interfaces. The main interface in each pilot displayed the alternative CRE portfolio, the overall preference score of both the current situation as well as the newly designed alternative. It also showed the added value of the alternative in comparison to the current situation.

The second pilot integrated more information in the main design interface. Each of the stakeholders could also see the preference score for their design variables for the current situation, the new alternative and the added value. The stakeholders could also select interventions in this interface for all of the lecture halls at the same time. The third pilot contained most information in the main design interface but did not visualize the portfolio alternative. In this interface, interventions could be made, the designed portfolio was displayed and they received feedback on the constraints. Additional information for each design alternative in this interface was: the location preference score, the decision variable, decision variable weights, the average decision variable values, and preference scores per decision variable. In this pilot, it was also possible to name and save a design alternative, to disable the design constraint on the number of locations, and to unselect all locations at once.

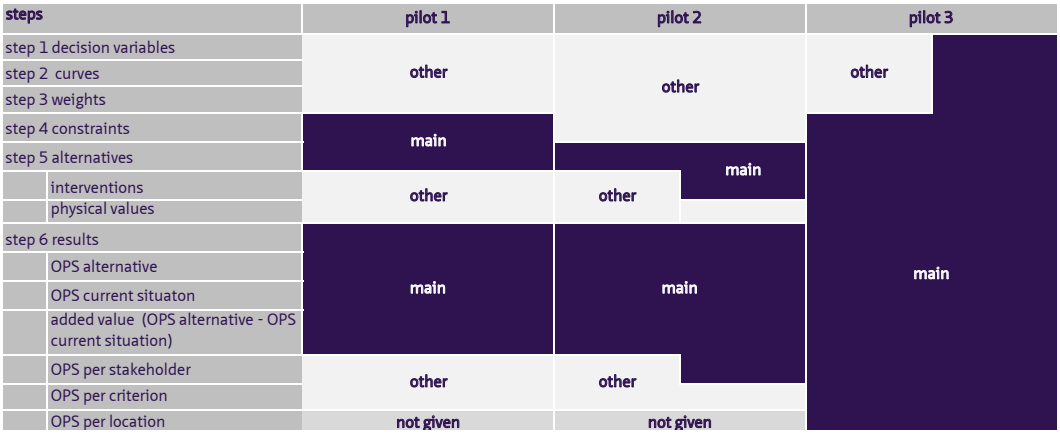


FIG. 6.29 Comparison of the information provided in the user interfaces

The additional design tools in all pilots have not been used much. It is recommended to research whether a reference model, as used in the first pilot, or other tools can be of more use if they are offered to the stakeholders differently or earlier in the process to the stakeholders when defining their design variables.