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EXPLORING THE STATE OF KNOWLEDGE AND GAPS REGARDING SUSTAINABILITY WITHIN VIENNESE CONSTRUCTION INDUSTRY

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Abstract. Different approaches to assess sustainability goals are found in construction sector, mainly related to energy efficiency through building technology and high-tech components, to low-tech strategies based on passive planning methods, the use of renewable raw materials, and building certification programs, which, however, are mainly an evaluation of already built objects. Austrian construction industry is extremely fragmented and heterogeneous, making research, development and innovation an issue for companies. The core of this project is to bridge the specific gaps in knowledge within Viennese construction companies about sustainable architecture and respond to these urgent needs by developing a customized postgraduate course. Within the first phase of the project, team meetings, a workshop and an online survey were run to assess the state of knowledge of Viennese companies. By doing so, information deficits were identified, companies' need for knowledge was determined and topics to be transferred were raised.

Keywords: Sustainability, knowledge gap, expertise, industry needs, customized modular course.

1. Introduction

In 2016, construction industry in Austria was responsible for 71.8 % of the total waste generated, being also the largest producer of CO_2 [1, 2]. Strategies towards circular economy and the end of the fossil fuel era must be urgently implemented. Use of renewable materials, improvement of thermal capacities of envelopes and reduction of operative carbon emissions among others, are imperative topics in the agenda of the city of Vienna [3]. The assessment of such requirements is critical and need especial expertise of the companies involved. According to few surveys involving Austrian construction companies [4, 5], the most relevant areas willing to be explored in this field are those related to low-tech approaches, energy efficient construction, ecological materials, and particularly life cycle assessment of buildings. Based on that, it can be stated that there is a willingness of further qualification in sustainable construction among the professionals of the sector. Besides, circular economy and building large-volume construction with renewable materials are relative ground-breaking issues, whereby targets and contents have not been widely explored, nor integrated in the curriculum of universities. For this reason the required expertise is rarely found within construction companies and seldom extended within the industry. Main goal of this project is to bridge this gap between crosscutting issues in sustainable architecture and high education training, looking holistically at all sub-areas and serving like a platform for exchange, transfer and expansion of expertise, as well as for permanent networking and regional cooperation between companies, experts, students, alumni and those interested on sustainable planning. This project aims to extract, process, structure and offer specific know-how from different disciplines to professionals and interested public. For doing that, three phases are followed. The first phase consists on the analysis and representation of the current situation of the planning offices in Vienna regarding the assessment of sustainability, their average existing level of knowledge and expertise and the specific topics of qualification willing to be explored. By doing so, knowledge gaps are identified. On this analysis relies the second phase, wherein customized public talks and interactive workshop series are developed, where the reported needs of qualification are intensively and interdisciplinary discussed with the purpose to identify enablers and barriers, and support the possible application of sustainable strategies. The third and last phase is focused on the further development of the findings reported in form of a post-gradual course, and the processing of collected knowledge to be offered to professionals and interested public within an open source platform. This paper describes the work done during the first phase, focused on the identification of knowledge gaps.

2. Background

Sustainability aims to offer next generation at least same or higher quality of life than at current situation. It can be roughly divided into the pillars of economic,

ecological and socio-cultural quality. Besides, technical, process and location quality play a major role in building sector. There are many different approaches to assess sustainability in terms of:

(i) energy efficiency, mainly controlled by building technology and high-tech components;

(ii) low-tech strategies, based on passive design concepts to maximize solar gaining and use of natural resources without high technological expenditure;

(iii) renewable raw materials and timber construction;

(iv) building certification programmes, which, however, mainly represent an evaluation of already planned objects; and

(v) flexibility in floor plan design and participatory planning processes.

A strongly arising aspect is the circular economy, which in construction means driving from the current linear system (cradle to grave) to a circular material and energy system (cradle to cradle), in which waste production, energy consumption and emissions are reduced by refusing, reducing and closing material and energy loops. Austrian construction industry is scattered, small-scaled and heterogeneous, where 89 % of all Austrian companies in the construction sector have 0–9 employees [6]. This situation makes research and development and thus innovation complicated. In addition, sustainable construction is currently struggling with the situation that every new building represents a prototype, meaning considerable additional work for planners, contractors and authorities. Issues concerned to fire protection and sound insulation are rarely assessed with tested products. For this reason, several companies have already developed own individual solutions for partial and detailed problems. Such in-house solutions could be shared, reducing complexity and increasing efficiency in design and construction. The existing certification and training courses found in Austria are on the one side usually focused on specific and separated sub-areas like life cycle costs, straw bale construction, energy performance certificates and passive houses, or on the other side are extensive and expensive. Workshops that can be booked individually covering different scales and areas of construction do not exist to date. Main goal of this project therefore, is to work as knowledge hub to drive an exchange, transfer and development of know-how between Viennese planning companies aiming to bundle the existing and dynamic expertise and to make it available to the public.

3. Analysis of current situation

In order to develop a customized curriculum and an adequate exchange platform adapted to the needs of the companies, an exhaustive analysis of the current situation was run. Goal was to estate the average level of knowledge and knowledge requirements about sustainable planning within the sector. Information deficits and learning needs were identified and key topics for deeper analysis and further exchange were uncovered. By doing so, the content of the curriculum and the exchange platform was assessed with the further willingness of collecting and discussing existing knowledge from different disciplines. Besides, didactic methods and dedication intensity were also asked aiming to also meet the requirements of the industry, raising awareness and disseminating information on sustainable building.

3.1. Data collection and target group

Aiming to assess correctly the industry needs from different disciplines, a three steps procedure was run when colleting the data:

(i) Collection and selection;

(ii) Discussion and development; and

(iii) Analysis and assessment.

Firstly, regular team meetings were run to collect ideas, best practices examples and measures for sustainable planning concepts, and select main topics and relevant actors. Based on that, a professional workshop was organized where external experts on the defined topics were invited to enhance discussion, unfold sub-areas, fix boundaries and support further development. All inputs were documented and structured stating the basis for the formulation of an online survey, which settled the fundamentals of this study. Its analysis and assessment determined the relevance of the selected topics and opened the repertory of new themes. Primary target group for the data acquire was planning offices, evolving different stakeholders from spatial and landscape planners, to developers, architects, structural engineers and other specialist planners. Secondary target groups were students, alumni, teachers and researchers in the field of sustainable planning. Nevertheless other professional groups and construction trades were invited to take part implementing a bottom-up and a top-down approach.

3.1.1. Collection and selection

Main objective of this step was to collect and filter existing knowledge and information on sustainable construction and select the essentials to make it available. Literature and online review, together with regular team meetings and brainstorming served to define the key themes under the following discourse: Sustainable architecture throughout the entire life cycle of a building englobes resource-related factors, socio-cultural issues and economic aspects. Main strategy to ensure sustainability is the implementation of renewable, regional and less energy intensive resources, combined with a comprehensive use of technical equipment. On the socio-cultural level, the inclusion of all individual citizens is key for an active participation and co-determination to design responsible, resource-saving and resilient cities. On the economic side,

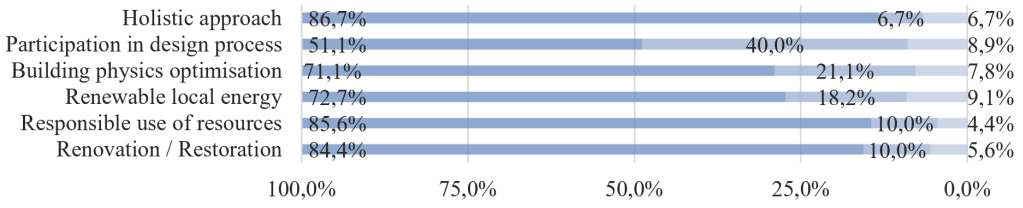

Figure 1. Definition of sustainability (grouped by rated values 1 to 2, 3 to 4 and 5 to 6, where 1 means not applicable at all and 6 fully applicable).

affordability and circular economic system need to be assessed.

3.1.2. Discussion and development

Main aim of this step was to work out the challenges and potential of sustainable buildings together with experts. An intensive workshop was held, where a total amount of 19 participants from various sectors of construction industry took part led by an experienced moderator. It also served as an official kick-off event for the public presentation of the project, where background, goals and methodology were introduced. The workshop was run in two rounds separated with a presentation of a project that served as best practices example in terms of ecological, economic and social sustainability. Within the first round of the workshop, all participants were organized in groups of 4 or 5 according to their expertise and experience enhancing interdisciplinary exchange. Groups were asked to discuss about their own concept of sustainable buildings and then asked to picture their developed concept, wherein the main essential characteristics were to be included and defined. Each concept was presented and discuss with all participants, what generated and consolidated a common picture of a sustainable building. Focus of the second round was the assessment of industry demands under the main concept of "needs and wants". A brain-walk-method was performed, where four main topics were explored on four different flipcharts, englobing each thematic one to three key questions. All participants were encouraged to move freely through the panels and give answers and inputs to the themes prescribed. The intensive and interdisciplinary exchange performed served as a basis to the development of the online questionnaire, while settling the fundamentals of the upcoming curriculum. At the same time, concrete needs regarding further education and research were defined and existing information sources were identified.

3.1.3. Analysis and assessment

Based on the discussion and inputs reported and documented by previous steps, an online questionnaire was developed following a 3-stage structure:

- Collection of personal data (profession, position, affiliation);
- Identification of the level of knowledge (own definition of sustainability and challenges when implementing sustainable strategies); and
- Analysis of further training demands (knowledge gap, needs and prerequisites).

Email addresses and LinkedIn profiles from potential interested professionals were selected and grouped. The survey was sent to a total amount of 15 500 contacts. By doing so, the project was also promoted within the sector, arising the awareness of the thematic.

3.2. Findings

423 people were reached and a total of 121 participants took part in the survey. The results are representative with the respective range of fluctuation within a confidence interval of 95.5 %.

3.2.1. Participants' professional background

Almost half of the participants taking part on the questionnaire are architects (43.8 %), being consequently the most representative group, followed by researchers and lecturers (20.6 %), and advisers (19.0 %). Further professionals took part in the survey representatively such as developers (16.5 %), specialist planers (12.4 %) and decision makers (9.1 %). A deeper analysis regarding to specific job positions showed that half of respondents are managing directors (48.6 %), while one fourth employees (27.9 %) and team leaders (23.4 %) respectively. On the question of how often participants deal with sustainability in their daily activities, 40 % said very often to often, while 20 % said little or very little, and another 40 % said only sometimes. These data represent a higher participation of stakeholders involved in the process of decision-making, what brings relevance to the survey and the project as they can work as enablers having relevant impact on further steps in production and construction processes.

3.2.2. Definition of sustainability and barriers to its implementation

For the definition of the multifaceted concept of sustainability in construction, almost two thirds of the respondents answered that a holistic approach with a responsible use of resources and an intensification of reuse, renovation and re-densification is fully applicable with an average of 5.38, 5.37 and 5.31 respectively, where 1 means not applicable at all and 6 fully applicable. In Figure 1 these most suitable definitions

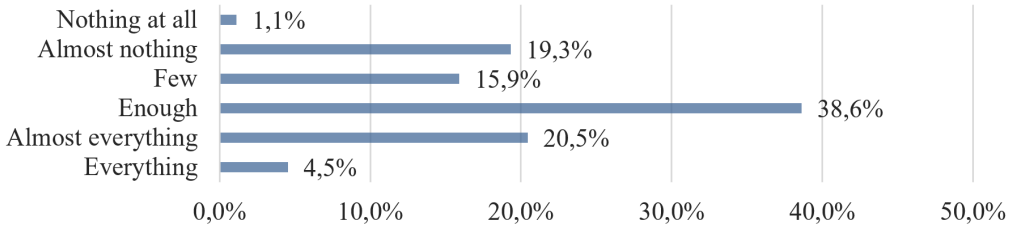

FIGURE 2. Ability to implement sustainable strategies.

of sustainability are represented, where the 86.7 % of all respondents scored a holistic approach with the highest values 5 and 6, followed by the responsible use of resources with 85.6 %, and renovation or restoration with 84.4 %. By these three definitions just around 4.4 % up to 10.0 % of all participants scored them with the lower values of 1 and 2, and 3 and 4. In further stage, the optimisation of buildings physics with an average of 4.91 was scored by the 71.1 % with the highest values 5 and 6, by the 21.1 % with 3 and 4, and by the 7.8 % with 1 and 2. Next, the use of renewable energy towards Zero-Energy and Plus-Energy got a value of 4.82, where the 72.7 % of participants rated them with 5 and 6, 18.2 % with 3 and 4, and 9.1 % with 1 and 2. Last, participation in design process was also highlighted as key aspects with an average score of 4.40, being valued the highest by the 51.1 %, with 3 and 4 by the 40.0 %, and with 1 and 2 by the 8.9 % of respondents.

The current situation regarding the capacity or ability of implementing sustainable strategies is rated just as sufficient by the participants, who stated an average of 3.7 on a scale from 1 to 6, where 1 means they cannot implement nothing at all and 6, everything. That means, more than half of participant reported that they are able to only implement an enough amount of strategies, while the other half meant many and very few strategies almost equally. Figure 2 represents the quoted answers.

Main reasons quoted as barriers for a successful implementation of sustainable strategies in design and construction were the lack of:

(1.) Awareness of the client (5.18 to 6);

(2.) Willingness to invest time and personnel resources (4.75 to 6);

(3.) Tax approaches and subsidies (4.72 to 6);

(4.) Marketing or public information (4.51 to 6);

(5.) Know-how of the executing companies (4.47 to 6);

(6.) Cost certainty (4.25 to 6);

(7.) Expertise of the planners (4.20 to 6);

(8.) Regulatory or normative basis (4.15 to 6);

(9.) Willingness to cooperate and share knowledge (4.10 to 6);

(10.) Specific education and training (3.87 to 6).

Access to specific knowledge and training opportunities play a comparatively small role, in contrast to the lack of awareness of the client. Therein lies the need to provide suitable accompanying measures, which depending of target groups are to be offered in different forms. In order to arise awareness among clients, dissemination, press work or events could be promote its consideration. Regarding to architects, trainings for effective advisory talks could be developed, based on conducting discussions, with argumentative discourses emphasising objective advantages and personal benefits, together with opposite foundations to debate, with the aim to bring out decision and generate positive conclusions.

3.2.3. Information sources

The sources of information consulted by the participants when aiming to design and build more sustainably are mainly specific literature and reports (70.2 %) and personal contacts (67.0 %). Second main information sources are further education formats and trainings like seminars or workshops (47.8 %), conferences, messes, and congresses (45,7 %), and online platforms (45.7 %), followed closely by contacting directly planners with experience and representative projects (43.6 %). Certification tools, guidelines, building regulations and standards were rated just by 33.0 % and 29.8 % respectively. Consulting personal contacts can be considered ambivalent since real sources of knowledge like certification tools, guidelines, etc. as well as building regulations and standards are not extensively used and therefore the level of knowledge of consulted contacts cannot be stated.

3.2.4. Knowledge gap and demand

By analysing the knowledge gaps, the life cycle assessment of constructions as shown in Figure 3 was reported by 59.3 % of the participants as the area with highest score, wherein the 19.8 % and 20.9 % considered there is enough to much available knowledge. Since the lifecycle assessment under a holistic approach was also quoted as an accurate definition of sustainability, it should be considered a fundamental aspect when developing a curriculum towards sustainable construction. Planning optimized life-cycle costs buildings was also considered by the 43.0 % of the respondents as an area with remarkable knowledge gap, wherein the 38.4 % stated there is enough knowledge,

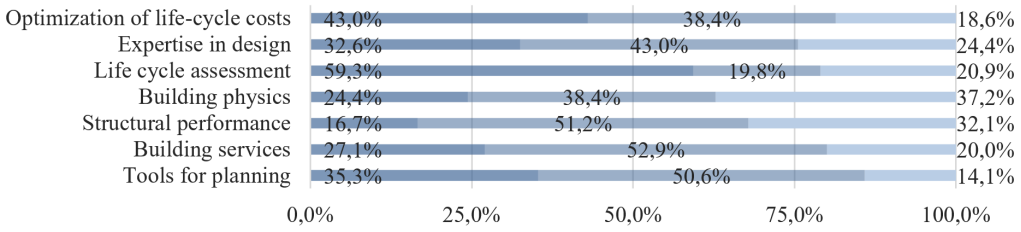

Figure 3. Knowledge gaps (grouped by rated values 1 to 2, 3 to 4 and 5 to 6, where 1 means high gap of knowledge and 6 no gap at all).

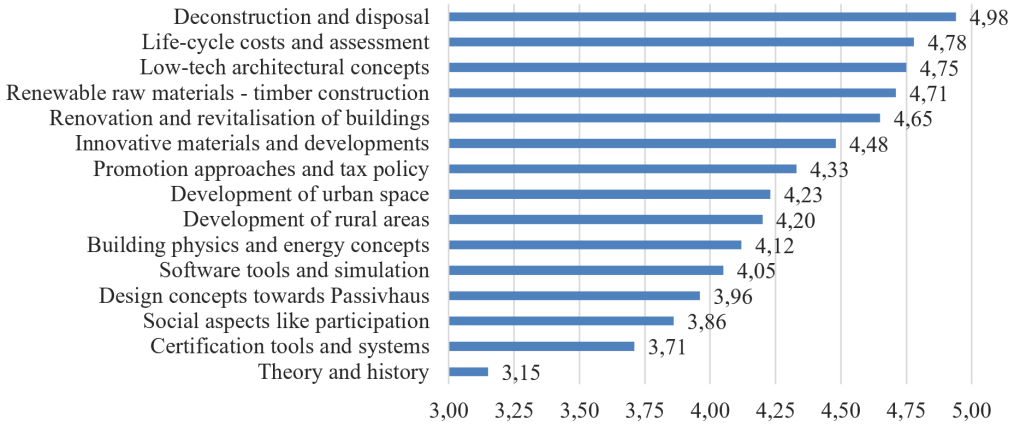

Figure 4. Demand of knowledge (quoted from 1 to 6, where 1 means not applicable at all and 6 fully applicable, and starting by 3.00).

and 18.6 % declared there are no relevant knowledge gaps. These statements make clear that a compromise between ecological and financial assessment need to be widely explored taking into account the whole lifecycle. Specific expertise on sustainable planning approaches and confidence on using tools and software for this purpose were reported by 32.5 % and 35.3 % respectively as aspects with high knowledge gaps willing to be assessed. However, 43.0 % and 50.6 % of the respondents considered that there is enough expertise, where the 24.4 % and 14.1 % respectively considered there are no need for further knowledge building in this regard. These two aspects are strongly related with the two previous ones, since they englobe the required competences and tools for achieving the desired lifecycle assessment rated with the highest scores. Finally, building services, building physics and structural performances were pointed out by 27.1 %, 24.4 % and 16.7 % each, meaning that even though being significant areas to consider when planning sustainably, enough expertise is already extended within the sector. That becomes evident with the 52.9 %, 38.4 % and 51.2 % which considered there is enough expertise, and with the 20.0 %, 37.2 % and 32.1 %, which stated there is no knowledge gap. These last aspects can also be grouped into a category which refers to the performance of the building. By doing so, three main groups are recognised where all key knowledge gaps can be embedded. The first and more relevant refers to the correct and accurate planning regarding the whole lifecycle of the building including its ecological and economic assessment. The second group relates to the required expertise and tools to be able to achieve those in the design. The third describes the structural, acoustic and thermal performance of a construction and its correlated building services.

By assessing the specific project phases, wherein to focus the implementation of strategies, all phases were rated as important, from basic analysis, to preliminary design, design planning, submission planning, detailed design, tendering, supervision of construction work and documentation, and project management, wherein basic analysis and submission planning was respectively rated with the maximal value (5.18) and the minimal one (4.12) with little difference between. That means all contents are above average in importance, having received the highest value for answer 6 (from 55 % to 28 %), except for submission planning, which highest percentage at answer was 4, what is still above average. The survey also highlighted areas represented in Figure 4 as key topics for desired further training, where almost all contents are important to an above-average extent, but without peak. The top demand is formed by a sextet with values between 4.94 and 4.48, namely:

(i) Deconstruction and disposal, englobing urban mining and dismantling and reuse and recycling of building components (4.98);

(ii) Life-Cycle Management including economic and ecological assessment (4.78);

(iii) Low-Tech planning strategies and climate-friendly

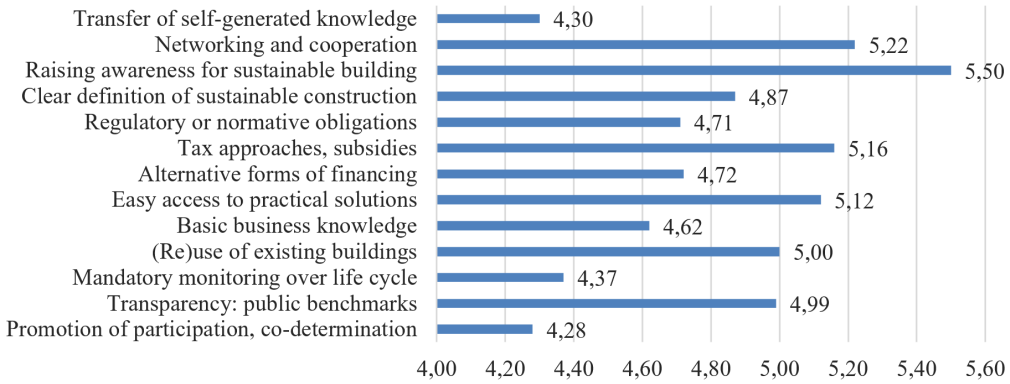

FIGURE 5. Effective strategies (quoted from 1 to 6, where 1 means not applicable at all and 6 fully applicable, and starting by 4.00).

architectural concepts (4.75);

(iv) Building with renewable materials, especially large volume timber constructions, assessing integral planning, structural performance, technical building services and building physics (4.71);

(v) Sustainable renovation, revitalisation and re-densification of existing buildings (4.65); and

(vi) Innovative materials and developments (4.48).

These data reflect a clear trend towards passive and responsible architectural design with low-tech planning strategies that use innovative environmentally friendly, renewable and low-carbon materials, addressing the full life cycle of the building and encouraging the extension of its lifespan through renovation, revitalisation or transformation (change of use) and re-densification, as well as through deconstruction and recycling of its building elements and components.

On the other side, the respondents rated with the relatively lowest value, the need for theory and history (3.15), the use of certification tools and systems (3.71), and the social participation in planning processes (3.86). The low rate of the first aspect could be justified through the presumed remoteness from practice and questionable applicability and practicability. Less comprehensible is the low interest in certification systems, which actually ease remarkable improvements within the overall process. These certification tools and systems are normally used after the project is planned and built in order to gain recognition, so that they do not impact the design development. With this in mind, it could be of relevant importance to implement these certification systems and tools proactively in order to manage different solutions within design and quantify their repercussions, helping in the decision-making process. Low rated were also social aspects like participation in planning processes, what does not fit with one of the main pillars of sustainability, namely the social sustainability, and is an issue that need to be assessed, having architects the chance to work as advisors to clients and society communicating benefits of building responsibly and arising the awareness regarding sustainability. In between we find a number of topics that were scored between 3.96 and 4.33, which englobe strongly related aspects like design concepts towards passive house, building physics and energy concepts, and software tools and simulation. Other aspects found within these scores relate to the development of urban and rural areas, and to promotional approaches and fiscal policies. The low scores for these aspects could be justified by considering that they are competencies that are beyond the reach of the planning offices, which are the group with the highest participation in the survey. Regarding the methodological design of the customized programme was answered by the majority with the preference of part-time continuing education courses as evening or weekend programmes (67.1 %), as well as the possibility of the completion of individual modules (59.5 %). Getting a certificate (44.0 %) was still rated as considerable relevant, while an academic degree (11.4 %) as low important. Undesirable was the fact of completing a large course of about 2 years (6.3 %).

3.2.5. POSSIBLE EFFECTIVE STRATEGIES

All given strategies were considered by the participants to be more effective than average with a punctuation between 4.28 and 5.50. Nevertheless, as shown in Figure 5, a top quintet can be recognized, formed by:

(i) raising awareness for sustainable building (5.50);

(ii) networking and cooperation (5.22);

(iii) tax approaches and subsidies (5.16);

(iv) easy access to practical solutions (5.12); and

(v) (re)use of existing buildings (5.00) instead of new construction with average values between 5.50 and 5.00 of 6.00.

Three of those topics, namely networking and cooperation, easy access to practical solutions and (re)use of existing buildings, are central concerns of this project, while the fact of raising client's awareness about sustainability was mentioned in the previous section as important topic to be addressed despite being scored

low, eventually through architects acting as advisor. The other theme requires a rethink about the inclusion of other stakeholders, especially politicians with regard to tax approaches and subsidies. Besides, owners and investors could be also key stakeholders to be included as target group in order to explore the possibilities towards (re)use of existing buildings rather than new construction. On the other side, even the three strategies considered as least effective, namely:

(i) Promotion of participation, co-determination and other democratic strategies (4.28);

(ii) Transfer of self-generated knowledge (4.30); and

(iii) Mandatory monitoring of the entire life-cycle of buildings (4.37),

were rated by almost 50 % with 5 and 6 (average values around 4.30), meaning that they are also considered of highly relevance. More transparency eventually through public benchmarks (4.99) was also stated as remarkably important, followed by a clear and common definition of sustainable construction (4.87), alternative forms of financing (4.72), by regulatory or normative obligations (4.71) and basic business knowledge (4.62).

4. Conclusions and next steps

Having explored and analyzed the knowledge gaps, demands and desired approaches of the planning offices during the first phase of the project, a series of interdisciplinary and interactive workshops will be organized within the second stage of the project with the aim of fostering tailor-made and diversity-adapted mutual knowledge transfer for design and planning firms. The main objective of this exchange of different viewpoints and professional approaches is to force a fruitful discussion in order to identify facilitating and constraining aspects of the implementation of the proposed strategies. In this way, the topics chosen for a more detailed analysis are grouped and will be discussed in thematic blocks. Experts on each topic will be invited to take part not only in the presentation of the contents, but also to actively interact in the discussion with the participants. In the same way, a building already realized and recognized for its sustainable quality will be chosen and gradually analyzed according to the topics relate to each thematic block. In this way, the participants together with the invited experts and the planners and builders of the building themselves will evaluate the implemented strategies by applying the acquired knowledge. Parallel to the analysis, new strategies will be proposed and their applicability will be jointly evaluated. Besides these interactive workshops, and according to the analysis run within the first stage of project, public lectures and expert talks are to be organized in order to raise general awareness and disseminate information about sustainability to interested public. Both methods of knowledge transfer will be evaluated through questionnaire and discussions to form the basis for the development of the customized postgraduate modules within the third stage of the project, which will be incorporated in the existing university training format. Furthermore, all knowledge gained throughout the whole project will be processed and offered to the public, so that they can serve as a basis for new services, research areas and product developments. In further steps within the third stage of the project, an extended literature review on educational theory and construction management will be performed to propose a suitable and functioning learning framework, where concepts like competence will be defined including its types, orders and domains of learning [7], to better address the didactic methods and contribute to the sector.

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