# Indoor soundscaping and its applicability in architectural practice

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# INDOOR SOUNDSCAPING AND ITS APPLICABILITY IN ARCHITECTURAL PRACTICE

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## ABSTRACT

Developing research field of soundscape leads to discussion on the applicability and standardization of the concept. The published (ISO 12913-1:2014, ISO/TS 12913-2:2018, ISO/TS 12913-3) standards on soundscape aims to standardize the related factors and methods for conducting research on open public spaces, in order to achieve palpable scientific grounds. However, since the focus is missing regarding indoor acoustic environments within the soundscape perspective, this major gap leads to the investigation of indoor soundscape methodology and its practical implementation. More in detail, there is an urgent need to consider the possibility of transferring data from soundscape research outputs to architectural design and application process. In the related previous research, indoor soundscape methodology and integration to architectural design and application process has been presented. This study focuses on the applicability of the indoor soundscape methodology, through (1) the identification of architectural design and application stages, and (2) relate these stages with the components of indoor soundscaping methodology. As a result, an application framework to be tested by case studies for indoor soundscaping integration to architectural practice has been presented.

## 1. INTRODUCTION

Applicability of soundscape approach is a growing research field, including testing and investigating the usability of soundscape standards [1-3]. Besides the studies, which are highly about urban soundscapes, the applicability of soundscape principles to indoor sound environments and usability by the profession experts are other key requirements in order to improve the soundscape quality of indoor spaces.

Starting point of this study is to investigate the applicability of soundscape approach by experts of architectural profession or related disciplines for enhancing indoor sound environments. Previous studies showed that [4, 5], the most crucial approach is to strengthen governmental enforcements such as regulations, standards and/or guidelines, in order to integrate soundscape principles with architectural practice. Published three ISO standards on soundscape study field [1-3], provide the essentials of the field and guide for "studies, investigations and applications". In this study the applicability of the soundscape approach to architectural applications, beside research is evaluated. Therefore, this study aims to act as a preliminary work for investigating the relations between the indoor soundscape principles and architectural practice through proposing a framework to test in for future works.

## 2. INDOOR SOUNDSCAPE CONCEPT

Identification of indoor soundscaping principles including affecting factors, descriptors and data gathering methods are essential in order to relate them with the entities/stages of architectural process. In previous works [4, 5], these principles were identified and merged based on the literature, however this study focuses more on ISO standards [1, 2] for investigating their usability in architectural profession.

While ISO 12913-1:2014 (Part 1) describes conceptual framework and affecting factors of soundscape approach, ISO/TS 12913-2:2018 (Part 2) concentrates on descriptors, indicators and data gathering. In relation with these published standards, indoor soundscape components can be classified in three main components as, "people", "acoustic environment" and "context". Additionally, "architectural characteristics" should be considered for indoor acoustic environments as proposed in the literature [4-7]. In table 1, these four main components and their sub-components are presented for indoor soundscape.

| Component | Sub-component |
|---|---|
| People | Socio demographic properties |
| | Temporal usage conditions |
| Acoustic environment | Sound sources *(needs revision for indoor soundscapes)* |
| | Acoustic parameters |
| | Psychoacoustic parameters |
| | *Building acoustics parameters* |
| | *Room acoustics parameters* |
| *Architectural characteristics* | *Function* |
| | *Constructive properties* |
| | *Building services* |
| | *Spatial properties* |
| | *Interior finishing and elements* |
| Context | Psycho-physiological qualities |
| | Affective qualities |

**Table 1.** Indoor soundscape components[1].

### 2.1 People

"People" is mentioned as participants in the standards, since it is more research-oriented [2]. However, in this

[1] Italics for the components that are included for indoor soundscape approach, others for the components that are indicated in ISO/TS 12913-2:2018.

research the target field is the professional practice. Thus, it might be more appropriate to use the terms, "user" or "client" instead of "participants". Information about the demographical characteristics of the intended people as user or client and temporal conditions are the key elements to predict their expectation, preference and soundscape perception regarding the case acoustic environments.

### 2.2 Acoustic Environment

"Acoustic environment" is the second component that conveys data on sound sources, acoustic and psychoacoustic parameters as identified in the standard [2]. However, several additions to the proposed parameters in the standard are needed in order to conduct an indoor soundscape study.

Sound sources are proposed to be classified as presented in Brown et.al's taxonomy model [8] for both urban and indoor acoustic environment [2]. Nevertheless, a revised classification model for indoor acoustic environment would be more convenient for architectural applications. In the standard, two alternative questionnaire protocols are presented for gathering data on sound sources including the sound types such as, "traffic noise, sounds from human being, natural sounds and others" which is extracted from Brown et.al's model [2]. To adapt this proposal to indoor acoustic environments, additional sources should be integrated for architectural practice such as, domestic sources through appliances and sounds originated from building services. Besides, these sources might be classified according to indoor and outdoor originated sound sources.

Furthermore, acoustic indicators to identify the urban acoustic environments are suggested in the standard [2]. These indicators include equivalent sound pressure level that rely on ISO 1996-1 [9], and psychoacoustic parameters. Considering indoor spaces, architectural acoustics parameters should be considered as well. These include room acoustics parameters such as, RT, EDT, SII, and STI and building acoustics parameters such as sound absorption coefficient (α), sound transmission class (STC), sound transmission loss (STL).

### 2.3 Context

Context, indeed, can be interpreted as the essential component of soundscape approach, which is linked closely with "people" and "acoustic environment". Context is in close relation with the soundscape descriptors as well, which aim to achieve the relation between acoustic environment and people/user through investigating the psycho-physiological assessments, meaning of a place and attachment to a place regarding sound environment [2]. As several studies in the literature [10-12] and standard [2] presents the descriptors as noise annoyance, perceived affective quality and soundscape quality. As for the indoor soundscape approach, architectural properties are expected to be included as a separate component, in addition to "context", "people" and "acoustic environment".

### 2.4 Architectural Characteristics

Architectural characteristics of an enclosure or space have crucial role for indoor soundscape research field through their effect on sound formation [6]. Moreover, architectural characteristics are expected to give substantial information about an enclosed acoustic environment. Therefore, architectural and spatial properties shall be assessed attentively while conducting a study on an indoor acoustic environment. The properties to be included in such studies can be classified as, function, constructive properties, building services, spatial properties, and interior finishing and elements.

Function is the primary and one of the major elements regarding spatial usage, to be considered in the initial phase of an indoor soundscape study. Through the detailed analysis on function, other related architectural properties and components would be observed and assessed. Constructive properties identify the structural composition of a building that is related with the geometrical form, as well as the structure-borne sound transmission properties. Building services would also affect the sound transmission between spaces. Furthermore, the specific elements that form the building services would act as potential sound sources that should be considered and controlled in soundscape design of an indoor environment.

Spatial properties represent the two-dimensional organizations, volumetric relations and properties, voids and openings which are expected to affect the sound formation and thereby the user perception. Finally, spatial components as interior finishing materials and elements, such as surface materials, furniture, appliances and/or devices, fittings and fixtures are the components that affect the overall indoor acoustic quality as the main sound sources of indoor spaces.

Through the analysis of previous standards and studies and detailed analysis on indoor soundscape approach and study field; four components within the indoor soundscape, (1) people, (2) acoustic environment, (3) context and (4) architectural properties are expected and/or investigated to be considered in architectural process which are practiced by the architectural experts or related disciplines in practice.

## 3. ARCHITECTURAL PROCESS

In this study, identification of architectural phases, which are used by professional experts, are aimed to investigate the relation between the components of indoor soundscape and whole architectural process. The "experts" refer to architects, interior architects and/or other related professionals, who are working as a decision maker on design and application/construction phases for enclosed spaces.

Royal Institute of British Architects (RIBA)' plan of works for 2020 indicates the stages as preparation, concept design, spatial coordination, technical design, manufacturing and construction, and handover (see Fig. 1).

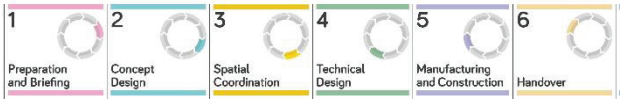


**Figure 1.** Plan of work for 2020 (adapted from [13]).

The first stage includes the determination of the client requirements, agreement of budget and preparation of the architectural/project outcomes, which will be needed in following stages. Concept design refers to preparation of architectural concept and receiving feedbacks from clients and stakeholders. As the third stage, spatial coordination is defined as the spatial organization of architectural and engineering information. Technical design is related with building systems. Finally, manufacturing and construction stage is indicated in RIBA plan of work before handover.

In Succar's "Project Lifecyle Phases" [14], the architectural stages are presented in three main groups as design phase, construction phase and operation phase. These three phases are described with the sub-phases, which can be seen in Table 2.

Besides RIBA and Succar's model, design phases of three architectural companies, which are used in their projects are presented to investigate the architectural process. Design phases of two companies [15, 16] are more similar with each other that start with "conceptual design" and "schematic design" as a research phase including architectural program, concept development, budget analysis and schematic plan drawings. The other stage is related with the preparation and determination of floor plans, application of conceptual ideas, 3D models and cost estimates, under the title "design development". After the consensus on design development, construction documents are prepared including all materials such as, furnishing and fixture details, other technical drawings and details to be used in construction phase. "Construction bidding/tender" follows the documentation, and finally, "construction administration" phase is presented as an architectural application phase in the design phases of HMH and Tailored companies (see Fig. 2, 3).

| **design phase** | **construction phase** | **operation phase** |
|---|---|---|
| conceptualization, programming and cost planning | construction planning and construction detailing | occupancy and operations |
| architectural, structural and systems design | construction, manufacturing and procurement | asset management and facility maintenance |
| analysis, detailing, coordination and specification | commissioning, as-built and handover | decommissioning and major re-programming |

**Table 2.** "Project Lifecycle Phases and sub-phases" (adapted from [14]).

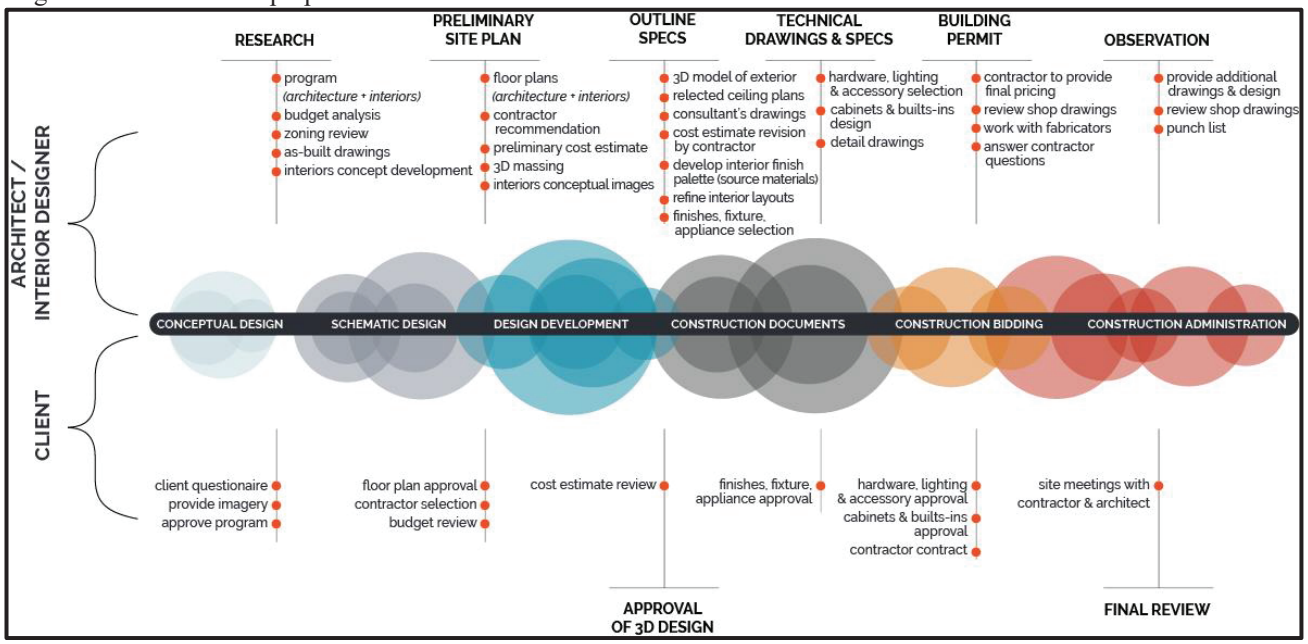


**Figure 2.** Design process of HMH Architecture and Interiors [15].

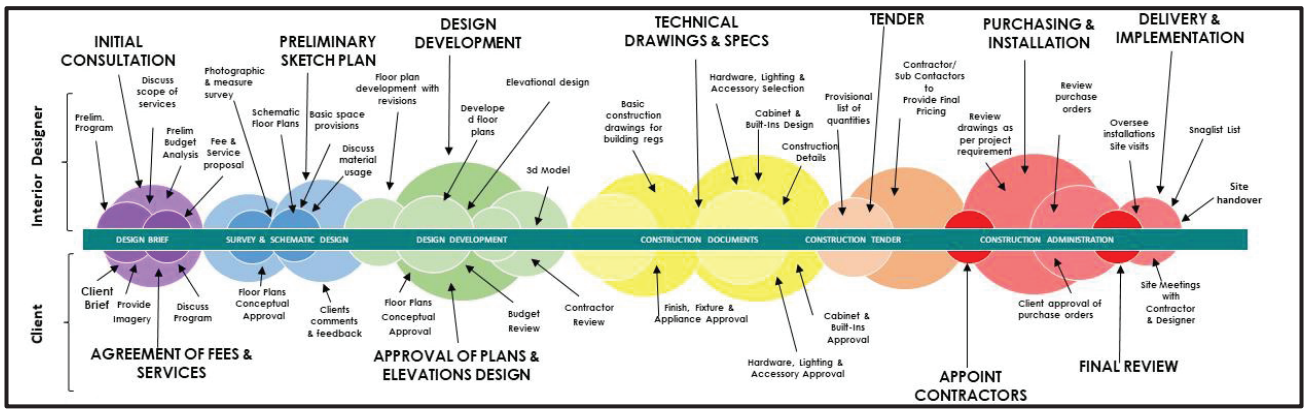


**Figure 3.** Design process of Tailored Interiors and Architecture [16].

One other example is the architectural phase demonstrated by Ruth Preucel Interiors [17], which has a more general approach (see Fig. 4). In this scheme five phases are indicated as plan that refers to schematic design, design development, documentation, building construction and installment.

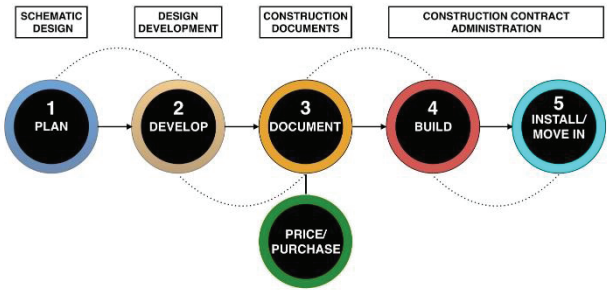


**Figure 4.** Design phases of Ruth Preucel Interiors [17].

As a result of the assessment of these samples and proposals on architectural process, an integrative model can be formed in four main phases as: (1) Conceptual Design (2) Design Development, (3) Documentation, (4) Construction and Application.

## 4. RELATION BETWEEN INDOOR SOUNDSCAPE COMPONENTS AND ARCHITECTURAL PROCESS

As a result of the evaluation of architectural design phases, possible relations can be interpreted between the indoor soundscape components and architectural process. Thus, it is expected that these relations will act as a preliminary framework to investigate indoor soundscape integration to professional practice.

Conceptual design is the initial phase of an architectural process. This phase is a research phase which involves conceptual design decisions formed by the clients' requirements and spatial requirements. Therefore, "people", "function", "sound sources" and "context" can be considered as indoor soundscape components within this phase. As the second phase design development refers the project phase including schematic design, spatial and three-dimensional organizations, and development of plans. These phases can relate with some of the sub-components of "architectural characteristics" and "acoustic environment". As for documentation phase, more technical details and information is needed since this is the preparation phase for construction and application, which involves the final decisions on materials, furnishing, fixtures, construction detailing, and technical drawings. Sub-components of "acoustic environment", "architectural characteristics" and "context" can be integrated in order to consider the soundscape approach in an architectural project. Finally, in construction phase, all components and parameters that were used in previous stages can be tested or verified.

| **Architectural Phase** | **Related Indoor Soundscape Components** | **Related Indoor Soundscape Sub-components** |
|---|---|---|
| **Concept** | People | All |
| | Acoustic environment | Sound sources |
| | Architectural characteristics | Function |
| | Context | Affective qualities |
| **Design development** | Architectural characteristics | Constructive properties |
| | | Building services |
| | | Spatial properties |
| | | Interior finishing and elements |
| | Acoustic environment | Building acoustics parameters |
| | | Room acoustics parameters |
| **Documentation** | Acoustic environment | All |
| | Architectural characteristics | All |
| | Context | All |
| **Construction** | Acoustic environment | All |
| | Architectural characteristics | All |
| | Context | All |

**Table 3.** Relation between architectural phases and indoor soundscape components and sub-components.

## 5. CONCLUSION

This study presents a detailed review of indoor soundscape components and architectural process. The applicability of indoor soundscape in architectural practice has been presented through relating indoor soundscape components with architectural phases so that the soundscape approach would not remain as an unimplemented research field for architectural practice. As the preliminary work, within the scope of this study, components that are specific to indoor soundscape has been highlighted as the architectural characteristics and its sub components, which are function, constructive properties, building services, spatial properties, and interior finishing and elements. In addition, architectural process and phases were investigated and identified to relate them for suggesting the applicability of indoor soundscaping in professional practice. As an outcome of this study, relation between architectural phases and indoor soundscape components and sub-components are presented. As the future work, following this preliminary study, a final scheme that will integrate the framework of the presented relations, and future case studies in corporation with professional experts is planned.

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