Taylor & Francis
Taylor & Francis Group

Architectural Engineering and Design Management

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/taem20

Exploring designers' finishing materials selection for residential interior spaces

Burçak Altay & Elif Salcı

To cite this article: Burçak Altay & Elif Salcı (06 Mar 2023): Exploring designers' finishing materials selection for residential interior spaces, Architectural Engineering and Design Management, DOI: 10.1080/17452007.2023.2181753

To link to this article: https://doi.org/10.1080/17452007.2023.2181753

ARCHITECTURAL ENGINEERING AND DESIGN MANAGEMENT
https://doi.org/10.1080/17452007.2023.2181753

Taylor & Francis
Taylor & Francis Group

Exploring designers' finishing materials selection for residential interior spaces

Burçak Altay[a] and Elif Salcı[b]

[a]Department of Interior Architecture and Environmental Design, Faculty of Art, Design and Architecture, Bilkent University, Ankara, Turkey; [b]Eczacıbaşı Vitra, Bilecik, Turkey

ABSTRACT

The increasing diversity of materials creates many possibilities and constraints that designers have to consider when selecting materials for projects. While the literature has investigated materials selection in engineering, product, and architectural design, knowledge is still lacking in interior design. Accordingly, this study focused on interior finishing materials with three objectives: (1) explore the determinants of materials selection in interior design, and within the residential design context, (2) identify designers' finishing material preferences and selection criteria for floors, walls, and ceilings; (3) investigate designers' criteria prioritizations while selecting materials. For this we conducted one-to-one interviews with architects and interior designers specializing in residential spaces. We first explored their material selection considerations in general. Second, we documented their material designations in residential project entry halls they had designed along with their selection criteria. Third, we presented an entry hall of a residential space for them to choose the materials while we questioned them about their materials selection priorities. The results reveal that the main determinants of materials selection include material-related, project-related, and designer-related factors. Moreover, materials choices and selection criteria vary between surfaces in space. Finally, the designers give the most priority to sensorial properties and the least to ecological properties. These findings expand our knowledge about materials in interior design, enhance the knowledge base for materials education, and have implications for designers and manufacturers regarding selecting and designing finishing materials.

ARTICLE HISTORY
Received 26 August 2022
Accepted 13 February 2023

KEYWORDS
Material properties; material selection; finishing materials; residential interiors; design prioritization

Highlights

- Architects' and interior designers' finishing material selection determinants, choices and prioritizations for residential interiors was investigated.
- In-depth interviews reveal material-related, project-related, and designer-related determinants influence finishing material selection.
- A greater variety of material choices are observed in a simulated project with no client and budgetary constraints when compared with actual residential design projects.
- Designer prioritizations of finishing material properties vary for walls, floors, and ceilings, with sensorial properties as the highest priority and ecological properties as the lowest priority.

CONTACT Burçak Altay burcak@bilkent.edu.tr Department of Interior Architecture and Environmental Design, Faculty of Art, Design and Architecture, Bilkent University, 06800 Bilkent, Ankara, Turkey

Introduction

Interior designers rely on the design possibilities created by the distinctive characteristics of different materials. Through meaningful material choices, designers create crucial differences in design quality and the resulting space (Ashby & Johnson, 2014). Consequently, an immense range of materials are now available, which creates many potentials and constraints to consider before selecting a material. It is therefore important for interior design practice to understand this selection process and the determinants of designers' material choices.

Research on materials properties and selection mainly centers on engineering (e.g. Ashby, 2005; Budinski, 1996; Lindbeck, 1995; Mangonon, 1999), products (e.g. Karana, Hekkert, & Kandachar, 2008, 2009, 2010, 2015; van Kesteren, Stappers, & de Bruijn, 2007), and architectural design (e.g. Hegger, Drexler, & Zeumer, 2007; Wastiels & Wouters, 2012). Within interior architecture, literature centers on the material properties of interiors (Binggeli, 2008; Godsey, 2013; Grimley & Love, 2013). While some materials-related studies address how materials are perceived, (e.g. Wastiels, Schifferstein, Heylighen, & Wouters, 2012), a few studies discuss the use of specific materials within designated space types (e.g. Fujisaki, Tokita, & Kariya, 2015; Harris, 2016). The consideration of architects' and interior designers' design practices regarding finishing materials is scarce (Sönmez & Tavşan, 2018). Also, none of the studies refer to the material choices that designers make in actual practice, thus the material designation in specific cases is not explored. Moreover, researchers have not yet identified the factors influencing designer prioritizations of criteria during decision-making.

In this study, we identify the determinants of interior designers' considerations during materials selection in their design practice. Moreover, with a focus on residential projects, we inquire about their finishing materials preferences for walls, floors, and ceilings, and their related prioritizations. Our findings contribute to interior design research and guide those involved in the design process to improve decision-making and ultimately the design outcome. The study has important implications for designers and manufacturers while selecting and designing finishing materials.

Literature review: materials selection and related considerations

Materials selection is an integral part of the design process, where decision-making may take place across different stages of design development that can vary based on the project requirements or the problem to address (Ashby, Bréchet, Cebon, & Salvo, 2004; Fernandez, 2006). In this section, we review the research on materials with a particular focus on selection criteria in several fields as well as considerations regarding residential interiors.

Researchers in various disciplines have categorized the considerations affecting materials selection. A majority take an objective approach based on technical and measurable properties, particularly prevalent in engineering. Various categorizations include physical, mechanical, chemical, and dimensional properties, codes and regulations, environmental and ecological properties, processing and fabricability, cost, and material availability (Ashby, 2005; Budinski, 1996; Mangonon, 1999).

In addition to the objective factors, recent studies have added subjective factors in materials selection like user experience and their associations with materials, called non-physical properties (Ljungberg & Edwards, 2003) or non-technical issues (Ferrante, Santos, & de Castro, 2000). As such, associations, emotions, meanings, user and cultural characteristics as well as aesthetic concerns are addressed to complement the engineering-based approach (Hegger et al., 2007; Karana et al., 2008, 2009, p. 2010; van Kesteren et al., 2007). Accordingly, Karana et al. (2008) identified the key determinants of materials selection as the material's manufacturing, ecological, intangible, and sensorial properties in addition to availability and consultancy. Relationships between meaning-making, manufacturing and sensorial properties were observed (Karana, Hekkert, & Kandachar, 2009). Moreover, exploring material experience as a driving aspect of conceptualizing design products has been proposed in education and practice (Karana, Pedgley, Rognoli, & Korsunsky, 2015).

Within the architectural discipline, based on evidence from architects' perspectives, Wastiels and Wouters (2012) suggest four dimensions; context, material aspects, manufacturing, and experience as material selection criteria. Context refers to the preconditions within which other considerations occur, such as cultural and physical context and the material's intended use. Architects' inclinations, economic conditions, the specific codes and regulations of a country, etc. are all considered under 'context'. However, Wastiels and Wouters (2012) do not dwell on the interplay of criteria and do not specify how these considerations are prioritized. They suggest: 'it would be interesting to verify how different considerations lose or gain importance over the course of the design and material selection process' (p. 591).

Different from products and architecture, an interior space can be identified distinctly by its defining surfaces: floors, walls, and ceilings. Finishes play a major role in determining spatial quality. Only a few studies have investigated finishes in interior design. Designers' criteria for materials selection, in general, have been studied by Sönmez and Tavşan (2018), based on interviews with designers. Within these, material features, budget, and concept were mentioned most frequently by the designers, whereas six additional criteria of function, space, natural material, local product, customer, and sustainability were expressed less. In another study considering sustainability in interior design, designers prioritized aesthetics, maintainability, thermal insulation, and durability when selecting materials under the three main categories of environmental, technical, and socio-economic sustainability (Rashdan & Ashour, 2017). Additionally, based on expert opinions regarding the application of laminate flooring in public and commercial spaces, Singer and Özşahin (2021) identified the key attributes, selection criteria, and prioritizations. The main criteria were economic, health and safety, physical, durability, and aesthetic properties. Additionally, Fujisaki et al. (2015) addressed perceptions and the sensorial dimensions of wood in interiors. Harris (2016) conducted a case study of a neonatal intensive care unit in terms of finishing materials for its floors, ceilings, walls, work surfaces, and upholstery surfaces.

Due to the gap in applicable and trustworthy information available for designers, an effort has also been made to set up tools/models to support decision-making during the design process. Studies include a building material evaluation and selection model for the Turkish construction sector (Tas, Yaman, & Tanacan, 2008), a database management system to choose amongst materials based on their indoor environmental quality performance in residential spaces (Lee, Kwon, Joo, Kim, & Kim, 2012), and development of sustainable assessment criteria for materials (Akadiri, Olomolaiye, & Chinyio, 2013). While the above efforts aim to support the decision-making of designers during design practice, many studies demonstrate that designers rarely rely on evidence obtained from research and academia. In the Australian context, Criado-Perez et al. (2020) point out that feedback from previous projects and consultant advice form the two foremost sources that designers base their practice on, whereas trade publications and newsletters, and academic suggestions are the least. Similarly, focusing on how architects in well-established design offices specify building products during design detailing, Emmitt (2006) asserts that designers pre-dominantly rely on their knowledge by using already known products and manufacturers. They present a reluctance to use products that are new to them, mostly due to safety perceptions and time pressures. The author suggests additional research into designers' everyday practices and decision-making processes.

A research domain regarding materials comprises the investigation of enhancers and barriers in selecting certain materials by designers, such as wood and bio-based materials in the Pacific Northwest and Sweden (Fernando, Hansen, Kozak, & Sinha, 2018; Markström, Bystedt, Fredriksson, & Sandberg, 2016). Additionally, research conducted in UAE notes material cost and project budget as barriers to sustainable project delivery, alongside a lack of available knowledge about green materials and problems in the skilled application during construction (Ahmed & El-Sayegh, 2022). To address the problem of knowledge acquisition, Peat (2009) proposes increasing the quality of sustainable product advertising to improve professionals' knowledge, so that they select and use sustainable materials more.

Material selection plays a significant role in residential projects where users/clients often interact with designers, and shape the overall design outcome (Erman, Altay, & Altay, 2004; Siva & London, 2011). Consequently, the comfort, health, and well-being of users are all affected by the quality of interiors (Rohde, Larsen, Jensen, & Larsen, 2020). Therefore, the actual material preferences of designers and users in residential interiors need to be investigated. However, within the design literature, very little information exists. In one study conducted in Saudi Arabia, experts from architectural and civil engineering backgrounds were introduced to seven finish materials where they confirmed that the first three most commonly used floor finishes were ceramic, marble, and porcelain in residential design (Al Orabi & Al-Gahtani, 2022). In another study, materials were chosen in Nigeria (Bako & Jusan, 2012) for a hypothetical future home, presented to the users through a 3-D visual. Ceramic tiles were the most preferred choice for floor finish, followed by marble; primarily due to ease of cleaning and maintenance. The authors point to the research potentials in residential interior spaces and suggest: 'a lot of research has yet to be done in the area of housing interior finishing' (p.184).

The above literature review identified the following gaps: An in-depth investigation of finishing material selection practices of architects and interior designers considering the interrelation of influential factors during the design process; a focus on residential interiors where the client and end-user quality of life are critically influenced by the material selection decisions; an emphasis on the holistic nature of interior space (considering walls, floors, ceilings) and complex nature of design activity via observing specific material applications in residential design; understanding the priorities and importance of criteria leading to the material designations. Accordingly, we address the following research questions in this study:

RQ1. What are the determinants of designers' finishing material selections for their projects?

RQ2. Within a residential design project, which finishing materials do designers prefer for interior floors, walls, and ceilings, and what are their selection criteria?

RQ3. When selecting finishing materials for interior floors, walls, and ceilings, how do designers prioritize their selection criteria? Do these prioritizations differ for each surface?

Materials and methods

To address the research questions, we adopted a mixed-methods approach within a face-to-face interview protocol. Within design research, face-to-face interviews, guided by open-ended semi-structured questions are widely used as an inquiry strategy to gain insight into the views, perspectives, and activities of stakeholders in design, including experts (Fernando et al., 2018; Siva & London, 2011; Sönmez & Tavşan, 2018). Moreover, discussions about specific projects shed light on the contextual factors and add depth to the study. Earlier research has included both discussions of built projects (Siva & London, 2011) and not-yet-built projects with 3-D models inviting material choices from participants (Al Orabi & Al-Gahtani, 2022; Bako & Jusan, 2012). We took advantage of both of these techniques to decipher designer decisions in their own working context which differed for each case project and a simulated project which was constant amongst designers.

Additionally, in criteria-based material studies, researchers who have worked on criteria identification have retrieved importance ratings from experts (Akadiri et al., 2013; Singer & Özşahin, 2021) with quantitative models without a specific project context. In the current study, prioritizations were adopted as an additional measure to compare the designers' general outlook with real-life implementations, as well as to observe how different criteria affected decision-making in design.

Participants

We used an expert sampling method to identify suitable participants who could provide the perspectives of designers about materials in their own practice. Expert sampling is widely adopted to

explore the views of professionals and stakeholders in the design field about their design process and practice, with a particular focus on material selection criteria and importance rating (Akadiri et al., 2013; Sönmez & Tavşan, 2018; Tas et al., 2008). Accordingly, 30 designers specializing in residential projects were selected from databases obtained from the Turkish Association of Architects in Private Practice and the Chamber of Interior Architecture. We prioritized participants from both architecture and interior design in order to complement findings with those in the literature, which is dominated by architecture. Moreover, in Turkey, both architects and interior designers are actively involved in the design and renovation of residential interiors. Accordingly, the participants included 16 interior designers and 14 architects based in Ankara, Turkey, aged 35–56 years with a minimum of 10 years of experience. The designers above an age range/professional experience were prescreened to ensure they had acquired residential design experience to share a residential project for discussion and make decisions in a relatively limited time within the simulated project. Before conducting the study, we specified the study procedures and received signed consent forms. Table 1 presents the participants' demographic characteristics.

Data collection instruments and setting

The study was conducted through face-to-face interviews with the second author. All interviews took place in the participants' architectural/interior design offices after initial contact.

The first part of each interview addressed the participants' general materials selection considerations in their practices. The three guiding questions were modified from Wastiels (2010) for an interior design focus: 1) In what stages of the design process are finishing materials chosen? 2) How do designers generally choose materials for their projects? 3) What properties do designers look for when choosing materials for a project?

The second stage explored an actual residential project implemented by each designer regarding their finishing materials preferences for walls, floors, and ceilings in entrance halls. Entrance halls were chosen since they are a transition between the public and the private home, which can show the designer's intentions with a variety of possible potentials and constraints. We also asked for relevant visual materials (drawings, photographs, etc.) to help understand the project type (villa, apartment, etc.). We inquired about their related considerations when choosing materials, and documented their selections on a checklist of materials.

For the third stage, we introduced a 3D visual of a residential project entrance and asked the participants to choose materials for the walls, floor, and ceiling (Figures 1 and 2). The instrument showed an entrance perspective produced by the second author, based on a plan scheme from a residential project introduced by Kicklighter, Baird, and Kicklighter (1990). We advised the designers to assume the project would be for an upper-middle-income family within a multi-housing project located in Çankaya, Ankara, with no budget constraints. The aim was to elicit the participants' materials selection criteria independent of client or budget. The participants selected their preferred finishing materials from a wide range of materials commonly used in the residential sector in Turkey, for

Table 1. Demographic Characteristics of Participants.

		Architect		Interior Designer		Total	
		N (14)	Percentage	N (16)	Percentage	N (30)	Percentage
Age	35–45	9	64%	12	75%	21	70%
(years)	46–56	5	36%	4	25%	9	30%
Sex	Female	4	29%	9	56%	13	43%
	Male	10	71%	7	44%	17	57%
Education Level	Bachelor	9	64%	9	56%	18	60%
	Master	4	29%	6	38%	10	33%
	Doctorate	1	7%	1	6%	2	7%
Experience	10–20	9	64%	10	62%	19	64%
(years)	21+	5	36%	6	38%	11	36%

Figure 1. Single-Story Residential Plan of the Simulated Project (Stage 3) (Adapted from Kicklighter et al., 1990, p. 35), Drawn by the Second Author.

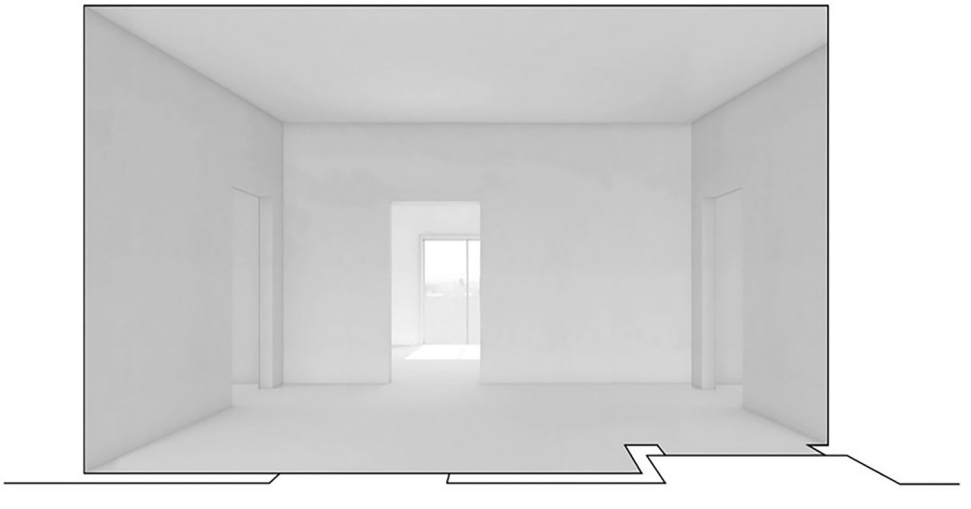

Figure 2. 3D Visual of the Simulated Project (Stage 3), Drawn by the Second Author.

ease of data collection process. However, the designers were free to choose any material, which was added to the list. Participants then wrote down their selection criteria for each material.

Having selected the materials, and written down the criteria/reasons of choice, the participants completed a questionnaire with a set of Likert-type questions about their prioritization of material properties for each surface. The original set included six properties (technical, sensorial, intangible, economic, ecological, and manufacturing) suggested by Karana et al. (2008), who based their categorization on the materials consideration literature in several disciplines. However, since the budget and the client were fixed at this stage, we excluded economic properties from the questionnaire and emphasized to the designers that they did not have a client or budget constraint. The components of each criterion were briefly listed in parentheses. Participants rated the degree of importance they gave to each material property. Table 2 presents an example question set for the floor, which was repeated for the wall and ceiling.

To summarize, the interviews first focused on the participants' practical experience of materials selection (Stage 1), continued with their material preferences and reasons within a real residential project (Stage 2), and ended with material preferences and prioritizations of selection criteria for an entrance area of a simulated project (Stage 3). Interviews took approximately 40-60 minutes per participant and were audio recorded.

Data analysis methods

We used a mixed-methods approach to analyze the data. For the qualitative data collected during the interviews and open-ended answers in the first stage, we applied the thematic analysis procedures suggested by Boyatzis (1998) and Braun and Clarke (2006), with an inductive approach. The second author transcribed the recorded interview data before analyzing it thematically. The data analysis procedure was carried out in steps. First, initial codes were generated from the entire data set. Through constant re-iteration, some initial codes formed main themes whereas some others formed sub-themes. This step produced a collection of candidate themes and sub-themes. To achieve reliability, the first author also carried out data analysis with a random sample of four interview transcriptions in the first stage. The codes and categories among the raters were checked for consistency at this point, and at certain intervals, until the main categories, themes, and sub-themes were finalized. The categories are expressed in Table 3 as well as the participant quotations in the next section.

The quantitative questionnaire data were analyzed using Statistical Package for the Social Sciences (SPSS) 23.0. Descriptive statistics were applied to observe the number of times each material was selected for surfaces in projects. Moreover, the participants' prioritizations of materials properties (technical, sensorial, intangible, ecological, and manufacturing) were also extracted as means from Likert-scale questions.

Table 2. Sample Questions for Prioritization of Materials Properties.

Question: When designing the space given above, rank your priorities according to the materials properties given below, ticking the most appropriate box in each row:

FLOOR	Extremely high priority	High priority	Moderate Priority	Low Priority	Very low priority
Technical properties of materials (durability, strength, conductivity, density …)	☐	☐	☐	☐	☐
Sensorial properties of materials (color, texture, smell …)	☐	☐	☐	☐	☐
Intangible properties of materials (emotions, meanings, culture, trends …)	☐	☐	☐	☐	☐
Ecological properties of materials (recyclability, sustainability …)	☐	☐	☐	☐	☐
Manufacturing properties of materials (easy to manufacture with existing facilities, assembly and finishing techniques …)	☐	☐	☐	☐	☐

Table 3. Categories, Themes and Subthemes of Designers' Materials Selection Determinants.

	Main Category	Theme	Subtheme
1	Material-related determinants (MRD)	Material properties (Mat)	Technical
			Sensorial
			Intangible
			Ecological
			Manufacturing
		Market properties (Mrk)	Cost
			Availability of materials
			Skilled workmanship
2	Project-related determinants (PRD)	Physical properties	
		Functional considerations	
		Client	
		Budget	
3	Designer-related determinants (DRD)	Material knowledge	Indirectly acquired
			Directly acquired
		Design approach	

Results

Materials selection determinants

Three main determinants were identified from analyzing the open-ended interviews based on the participants' practical experience of selecting finishing materials: Material-related determinants (MRD), project-related determinants (PRD), and designer-related determinants (DRD). Each category had several directly related themes and subthemes defining them in more detail (see Table 3).

Material-related determinants

MRDs included consideration of material and market properties. Under the theme of material properties, the participants reported being strongly influenced by technical, sensorial, intangible, ecological, and manufacturing properties.

Regarding technical properties, the participants mostly focused on physical and mechanical performance, with durability being a determining selection factor. As one designer explained:

> I take particular care to select hard *(MRD; Mat-Technical)* material where the circulation is high *(PRD; Function)*. For example entrances … because entrances are the places where the house is exposed to the most circulation and therefore the material strength is very important *(MRD; Mat-Technical + PRD; Function)*. At this point, the most important thing for me is having durable material.

The participants selected materials' sensorial dimensions considering vision (color, glossiness), sound (hearing footsteps, absorbing sound), touch (roughness, warmth), and smell, as illustrated by these comments:

> I love to add texture to my projects *(MRD; Mat-Sensorial)*. Especially wallpaper is a material I prefer at this point, because it gives you the chance to create depth with its texture and I think this creates a domestic atmosphere *(DRD; Design approach)*.

Sensorial properties were closely linked to the materials' intangible properties that have meaning for the users. Current trends, historical cultural influences, and expected emotional responses were involved. The participants also considered the materials' sustainability and ecological properties, particularly in terms of health concerns.

> It is very important that a material does not harm human health *(MRD; Mat-Ecological)*. For example, I try not to prefer laminate flooring too much. Because there are a lot of chemicals in them. I'm trying to prefer solid parquet instead.

Materials were selected predominantly for their manufacturing characteristics, particularly regarding their application in the project. Assembly and finishing techniques as well as availability in the

desired size, color, etc. were crucial. Including this property, overall, a multitude of materials property sub-themes influenced the participants' materials choices:

> I preferred marble because I wanted to create a pattern on the floor and marble is a very suitable *(MRD; Mat-Manufacturing)* and popular material *(MRD; Mat – Intangible)* for that. It can be cut to the desired size and pattern. You can create your own pattern on the floor *(MRD; Mat-Manufacturing)* and it is durable *(MRD; Mat-Technical)*. So … this provides many options for us. For example, we can also use marbles of different colors and textures *(MRD; Mat-Sensorial)* within the same surfaces.

The second MRD theme was market properties. As a sub-theme, cost was one of the mentioned factors with respect to decision-making. With the fluctuating market, the cost was an impact 'the moment client came into the picture'. For example, after the primary materials were chosen, the specific material cost amongst different manufacturers could be investigated. Moreover, being able to find and apply the material was crucial, especially in terms of the project schedule. For the designers, a material always needed to be easily accessible; otherwise, they could change their selection. Skilled workmanship was also important to ensure a high-quality project outcome; access to reliable manufacturers with trustworthy personnel was critical. As a designer commented:

> In the market, we cannot reach the people who apply this material properly. For example, I am sure you are aware of decorative paintings. Today, we see so many examples of it. Especially, creating a concrete appearance *(MRD; Mat-Sensorial)* on the walls is very popular today *(MRD; Mat-Intangible)*. However, if you cannot find a skilled laborer to create this appearance, you cannot get what you are expected to see *(MRD; Mrk-Availability of skilled workmanship)*.

Project-related determinants

PRDs were influential in materials selection. The four main themes referred to the project's physical aspects, functional and program-related elements of the project spaces, client requests and input, and budget. The physical properties included primarily the site, location, project size and plan layout, and existing surface characteristics. Since most interior design finishes were applied to existing buildings, their characteristics determined the preferences:

> It was an old building, so the corridors are really narrow *(PRD; Physical)*. 60 × 60 ceramics are better looking *(MRD; Mat-Sensorial)* but if I used a ceramic of this size, I had to cut *(MRD; Mat-Manufacturing)* them to fit in the corridor space. I, therefore, chose 45 × 45 ceramic tiles and used them throughout the circulation area *(DRD; Design approach)*.

As for functional characteristics, the participants considered how to match materials to the use of a specific space. This included ease of cleaning and repair, a concern for appropriate intangible characteristics (meaning-related), and suitable sensorial characteristics for the specific function and surface.

> My considerations on materials change according to the function this material will be used for *(PRD; Function)*. For example, if I use marble on a wall as a board panel, I choose a marble by just looking at its appearance *(MRD; Mat-Sensorial)* because, at this point, my expectations focus on aesthetic concerns. Alternatively, if I use marble as a floor finish, I first consider its strength and durability *(MRD; Mat-Technical)*. Then I consider its visual appearance *(MRD; Mat-Sensorial)*.

An interlinked set of project-related themes that affected all other determinants concerned clients and budgets. Designers often negotiated with these to achieve the desired interior quality with the client's aesthetic and economic preferences, meanwhile maintaining sensitivity to function:

> The customer's tastes are particularly decisive in residential projects because, at every stage of the design process, you have to meet them face to face (*PRD; Client*). In some cases, as a result of these meetings, I sometimes have to choose materials that will not satisfy me visually *(MRD; Mat-Sensorial)*. However, I never choose a material that I know it is not proper for the function where the material is used *(PRD; Function)*.

> I like marble more *(DRD; Design approach)*, but unfortunately, it is an expensive material *(MRD; Cost)*. Therefore, in projects with a limited budget *(PRD; Budget)*, I can choose ceramic instead of marble.

Designer-related determinants

DRDs emerged as a major influence on how the participants select materials. In that respect, designers relied on the knowledge they acquired indirectly from various sources as well as the knowledge acquired directly, via first-hand material experience and application.

Many participants learned about materials indirectly by relying on sources like websites, books, magazines, and materials datasheets to keep up-to-date and be aware of the properties of both longstanding and new materials on the market. They then used their practical knowledge to achieve the desired result by applying materials. In both respects, designers relied on past experience, as many explained:

> I tried to use materials that I know. I mean … There are some material suppliers that we collaborate with. They regularly send us material samples and when we start a new design project, I consider these materials, or sometimes I use websites to find materials *(DRD-Material knowledge-Indirect)*.

> When choosing the materials, I take into account the information I have acquired from my previous experiences. For example, I can reuse a parquet for another project if I am sure about its performance. Likewise, I can choose other colors of the same parquet, which I have observed to be aesthetic from earlier experience *(DRD-Material knowledge-Direct)*.

Finally, an inseparable part of each designer's professional identity was their own design outlook, preferences, values, and intentions. Their material choices were often based on the main conceptual principles that they wanted to reflect through their designs:

> I personally love (*DRD; Design approach)* using the same material for the whole circulation area because it shows the space as larger than it is. In this project, again, I preferred (*DRD; Design approach)* to use one material for both entrance and corridor spaces.

The designer's conceptual approach was often merged with the end-user preferences to arrive at the desired outcome:

> [T]he user was a collector *(PRD; Client)*. Therefore, the concept of the project focused on presenting these collections most effectively and aesthetically (*DRD; Design approach)*. For this reason, we chose soft-colored paint on the walls. We also used wallpaper, particularly on the walls where there was no collection to present *(MRD; Sensorial)*.

The above extracts reveal the complex nature of material selection in design practice. For each unique project, the designer evaluates a multitude of factors to choose materials for every interior surface in every space. The next section considers these choices in specific situations for each designer in their actual projects (Stage 2), and a simulated project (Stage 3).

Materials preferences and selection criteria

The participants were first asked to share their materials selections for a real-life residential project entrance area of their choice. Their choices included 22 villas and 8 apartments completed between 2008 and 2019. Afterward, they were asked to select finishing materials for the simulated project entry area. While some designers looked at the entrance visuals and wrote down their proposed materials, others created quick sketches with material designation studies to make their preferences. Figures 3 and 4 show two participants' proposals for the simulated project.

Regarding RQ2, Tables 4–6 summarize the participants' floor, wall, and ceiling finishing materials preferences. Since more than one material could be applied to each surface, the total percentages were calculated separately for each surface.

Ceramic, marble, and wood were the first three choices for entrance hall floor material, although ceramic tiles were the first choice in actual projects whereas marble was in the simulated project. Moreover, the overall range of materials and divergence from the three main material choices was greater in the simulated project.

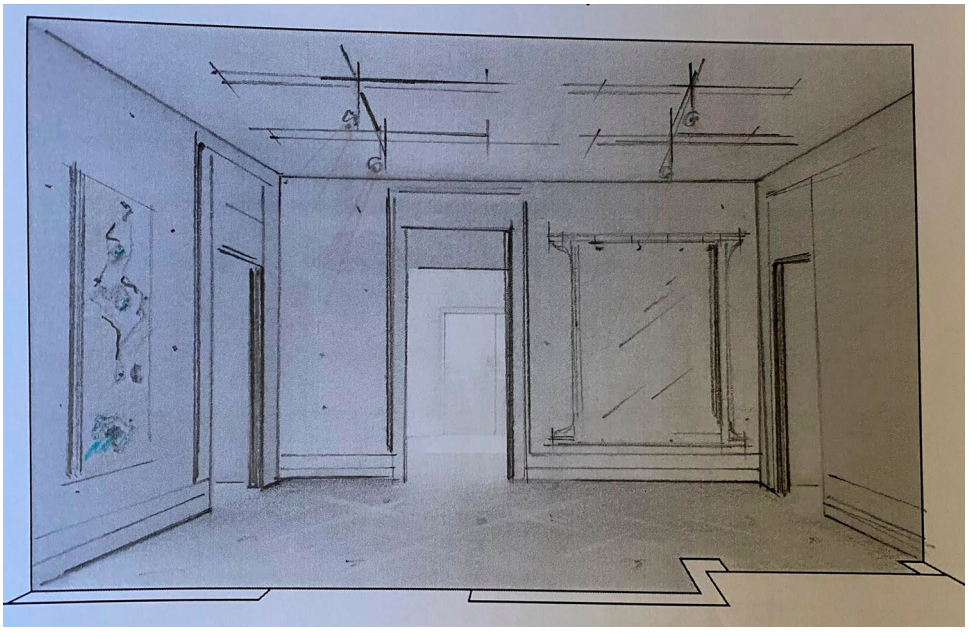

Figure 3. Participant #3's Design for the Simulated Project.

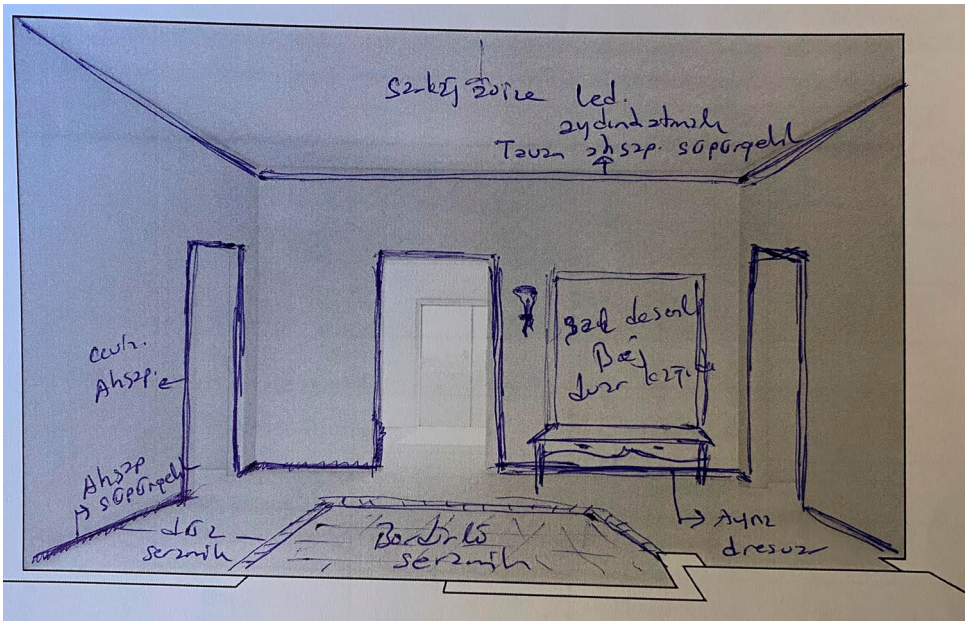

Figure 4. Participant #20's Design for the Simulated Project.

Regarding walls, paint, wallpaper, and wood were the top choices in both cases. As with flooring, participants chose a wider variety of wall finishes in the simulated project. Increased use of marble and mirrors, as well as the additional use of exposed concrete and epoxy were apparent.

Table 4. Floor Materials Preference Frequencies in Actual and Simulated Projects.

FLOOR	Actual project		Simulated project	
	N (38)	Percentage	N (50)	Percentage
Ceramic	13	**34%**	8	16%
Wood	12	31%	8	16%
Marble	10	26%	16	**32%**
Epoxy	1	3%	5	10%
Granite	1	3%	9	18%
Textile	1	3%	0	0
Concrete	0	0	4	8%

Note: In some projects, more than one finishing material was used

Table 5. Wall Materials Preference Frequencies in Actual and Simulated Projects.

WALL	Actual project		Simulated project	
	N (48)	Percentage	N (70)	Percentage
Paint	16	**34%**	16	**23%**
Wallpaper	13	27%	13	19%
Wood	12	25%	16	**23%**
Marble	3	6%	7	10%
Decorative stone	2	4%	3	4%
Ceramic	1	2%	2	3%
Mirrors	1	2%	9	13%
Concrete	0	0	3	4%
Epoxy	0	0	1	1%

Note: In some projects, more than one finishing material was used

Table 6. Ceiling Materials Preference Frequencies in Actual and Simulated Projects.

CEILING	Actual project		Simulated project	
	N (33)	Percentage	N (42)	Percentage
Paint	27	**82%**	29	**69%**
Wood	3	9%	6	14%
Concrete	1	3%	2	5%
Wallpaper	1	3%	1	2%
Aluminum	1	3%	1	2%
Mirrors	0	0	2	5%
Vinyl	0	0	1	2%

Note: In some projects, more than one finishing material was used

For ceilings, paint was the most frequently chosen finishing material, followed by wood in both real-life and simulated projects. The participants selected from a narrower range of materials for ceilings than floors or walls.

Regarding their reasons for these choices, the designers listed durability, strength, and sensorial (visual and tactile) properties as the primary material properties. Availability in the market, particularly to find a range of alternatives, was also a critical reason for choosing materials, as a market property. The designers also listed intangible material properties, such as 'familiar', 'homelike', and 'trendy/popular', particularly pertaining to wood and wallpaper. Given the entrance hall function of the space, PRDs influenced the choice of wall and floor finishing materials, particularly being easy to clean, maintain, and repair. For floor surfaces, durability was an essential consideration to withstand heavy circulation. Consequently, participants tended to choose more rigid materials like ceramic, marble, or laminate. Their choices in real-life projects were also determined by other PRDs, particularly economic factors and client preferences, whereas these were not factors in the simulated projects.

Table 7. Choices Regarding the Number of Materials across Surfaces.

		Actual project		Simulated project	
	Material choice	N (30)	Percentage	N (30)	Percentage
FLOOR	Single material	**21**	**70%**	**20**	**67%**
	At least two materials	9	30%	10	33%
WALL	Single material	**17**	**57%**	7	23%
	At least two materials	13	43%	**23**	**77%**
CEILING	Single material	**25**	**83%**	**20**	**67%**
	At least two materials	5	13%	10	33%

When observing the material choices between different surfaces and amongst actual and simulated projects, the holistic decision-making of designers emerged as a crucial finding. Often, designers had more than one material designation on a surface. Table 7 shows the distribution of material choice number across the surfaces.

A variation in material applications between surfaces as well as between actual vs. simulated projects was observed. For floors, over a dozen combinations were proposed such as wood + textile, ceramic + marble, with triad combinations of wood + marble + granite, etc. Similarly, over a dozen combinations were proposed for walls, which included wood + paint, stone + wall paper + paint, wood + wall paper, etc., with additions of mirrors, artworks, etc. to any background material choice. For ceilings, a common proposal was to have a foreground of one material, such as wood or mirrors, with a background of paint or wallpaper. Moreover, many noted the specific design intention of integrated lighting (cove lighting, exposed lighting, etc.).

Reasons for the variety of choices expressed designers' experiential and sensorial sensitivity, where a decision on one surface was made upon its relation to another. As one participant commented:

> The wood on the floor is used to separate the circulation route from the entry hall subspace, which is granite. The use of natural stone and wood with wallpaper is to preserve the asymmetric balance of the opposite wall. The ceiling has hidden lighting fixtures with spray plaster and paint to maintain textural balance.

Prioritization of material properties when choosing materials

In the final stage, we investigated material selection prioritizations. We especially examined if there were any differences in designer prioritizations for material properties when choosing wall, floor, and ceiling finishing materials in the simulated project.

As Figure 5 shows, the participants prioritized sensorial properties (floors $M = 4.57$, $SD = 0.62$; walls $M = 4.83$, $SD = 0.62$; ceilings $M = 4.20$, $SD = 0.80$) the most for all surfaces. However, for wall surfaces, sensorial properties were among the highest of all three surfaces. That is, sensorial properties were more important in choosing wall materials than for floors, followed by ceilings. Technical properties were the second priority for the participants (floors, $M = 4.23$, $SD = 0.81$; walls, $M = 4.00$, $SD = 0.91$; ceilings, $M = 3.93$, $SD = 0.94$). As with sensorial properties, the participants prioritized the intangible properties of walls ($M = 3.83$, $SD = 0.98$) more than floors ($M = 3.70$, $SD = 0.95$), and ceilings ($M = 3.33$, $SD = 1.15$). Regarding manufacturing properties, the participants gave the same prioritization scores for walls ($M = 3.77$, $SD = 1.38$) and floors ($M = 3.77$, $SD = 1.13$) but slightly higher scores for ceilings ($M = 3.93$, $SD = 1.14$). Finally, for all surfaces, the participants gave ecological properties the lowest priority (floors $M = 2.90$, $SD = 1.06$; walls $M = 2.93$, $SD = 1.11$); ceilings ($M = 2.97$, $SD = 1.03$).

Designer prioritizations support their interview comments where they express the significance of conceptual design ideas for material preference. Thus, designers consider material combinations based on sensorial properties such as tactile and visual atmosphere, and intangible properties such as trends, sense of warmth, etc.

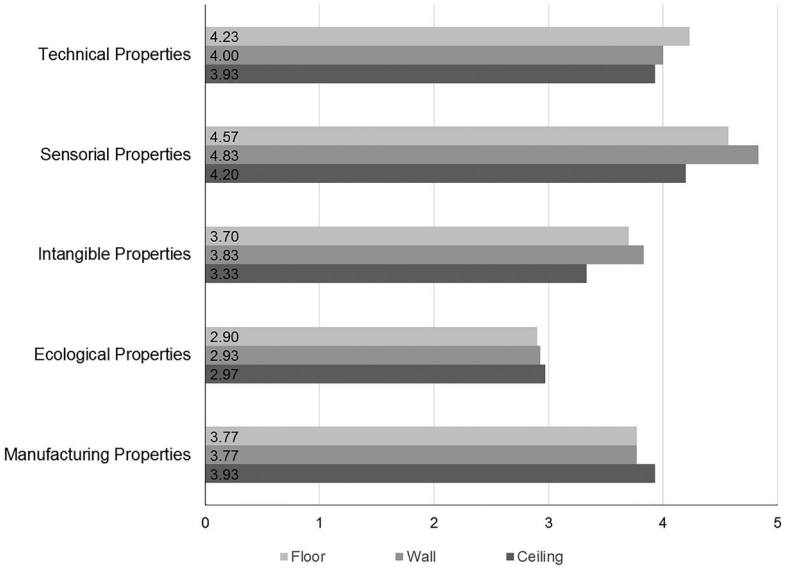

Figure 5. Mean Prioritization Scores for Materials Properties for Floors, Walls, and Ceilings for the Simulated Project.

Discussion

This study explored designers' decisions while choosing finishing materials for walls, floors, and ceilings, with a focus on residential design. The analysis provided rich qualitative and quantitative findings regarding the participants' overall outlook, their finishing materials decisions in specific projects that they had designed, and their choices for a simulated residential entry hall project. In particular, the findings provide new knowledge regarding the designers' experience of materials selection determinants, their actual material choices, and their prioritizations of materials considerations.

Findings regarding RQ1 reveal three categories of determinants – materials-related (MRD), project-related (PRD), and designer-related (PRD) – influence designers' materials selections. The MRDs include two themes: material properties and market properties. All the material properties; technical, ecological, sensorial, intangible, and manufacturing are interrelated. Rather than separating them, as in Hegger et al. (2007) and Wastiels and Wouters (2012), we consider them together, as recommended by Karana et al. (2008). Our study supports the literature (Budinski, 1996; Hegger et al., 2007; Karana et al., 2008) that proposes market properties as a crucial factor affecting decision-making. In our study, the material cost, material availability, and skilled workmanship were distinct sub-themes under market properties, particularly regarding interior finishes. Thus, even if a material's intrinsic properties are desirable, it is essential for designers to be able to find it and skilled workers to apply it, all within the expected cost range.

Project-related determinants refer to the physical, functional, client, and budgetary concerns of a specific project. This is somewhat different from the category of 'context' proposed by Wastiels and Wouters (2012), which includes a vast range of actors and situations.

The third category is designer-related determinants in which materials knowledge and design approaches were emerging themes. The critical impact of direct experiential knowledge and indirect knowledge of designers on their material choices should be considered within the construction sector, particularly when exploring the enhancers and barriers to the use of certain materials (Ahmed & El-Sayegh, 2022; Emmitt, 2006; Fernando et al., 2018; Markström et al., 2016; Peat, 2009). Moreover, the impact of designers' approach on material selection is not considered at great length in literature, with only a brief acknowledgment for architecture (Wastiels & Wouters,

2012) and interior design (Sönmez & Tavşan, 2018). The current research reveals the importance of the designer approach (i.e. stylistic preferences, aesthetic priorities, etc.) in close interaction with the user/client preferences. Moreover, the designer's approach is likely to be influenced by age, gender, professional background, practice experience, etc. For example, Tonetto, Brust-Renck, Ruecker, and Pacheco (2021) point out the different approaches regarding thinking styles and decision-making between product designers, architects, and engineers while developing a product. They suggest further research into differences in design approaches for heterogeneous demographic characteristics. Accordingly, our findings confirm the impact of designer-based determinants that influence the design process.

Regarding RQ2, concerning material choices, our study used a novel method of documenting material choices in actual projects carried out by designers as well as a simulated project. Acknowledging that economic demands often influence and sometimes limit materials selection in professional practice (Hegger et al., 2007; Wastiels, 2010; Wastiels & Wouters, 2012), we explored designer selection in a simulated project with no budget constraints to compare the participants' materials selections with those in their own completed projects.

The findings showed that designers had certain material preferences for each surface (e.g. marble, wood, ceramic, and granite for floors; paint, wallpaper, and wood for walls; paint and wood for ceilings). Surprisingly, the most common choices did not vary extensively across the actual and simulated projects, except for an increased preference for marble and granite flooring over ceramic, which may be an indicator of less concern for cost. Overall, the number and variety of materials within the proposed designs were larger for the simulated project. A reason for the difference may be the freedom to choose materials without the constraints of a budget and clients in the simulated project where designers could express their conceptual approach.

One surprising study finding was the designers' choice of more than one material on every surface in many cases. This is noteworthy since the literature on materials research does not address the interrelations of different materials as a feature in decision-making. The inclusion of real-life cases and simulated project case was instrumental in arriving at this finding, which was not apparent via inquiry of general perspectives. Therefore, a multi-dimensional contextual approach to material selection in interiors with a sensitivity towards the atmospheric effect of the space on users is called for, particularly in the efforts to provide criteria and assessment models for material decision-making.

Regarding RQ3, the study showed that designers have different priorities for each material and surface. Designers prioritize materials' sense-related properties. Overall, sensorial properties were ranked higher for walls than for other surfaces. The potential to attract attention visually when entering a space seemed to distinguish walls from other surfaces. Conversely, sensorial properties were ranked lowest for ceilings. This may be because ceilings lack the tactile component of walls and floors and are out of the direct visual field. The second-ranked priority was technical properties for all surfaces, followed by intangible properties, and manufacturing properties. The requirement of sensorial properties in material selection as a priority is a finding that is also suggested by Karana et al. (2008) in product design. Regarding the prioritization of laminate flooring in commercial buildings, however, experts prioritized health and safety, durability properties, economic properties, and physical properties before aesthetic properties (Singer & Özşahin, 2021). The difference between the studies may be due to several factors; the difference in commercial-residential space, the research being based on a general perspective as opposed to a specific case study, and differences in the professional backgrounds of expert groups.

In contrast to the importance given to sensorial and technical properties, the participants gave ecological properties like non-toxicity and sustainability the lowest priority, even though they claimed that ecological properties are important factors in materials selection during their interviews. Therefore, appropriate venues are needed to disseminate sustainable materials research to impact designers' actual decision-making. Accordingly, manufacturers are suggested to foreground sensorial properties when communicating with designers. Moreover, based on the findings

regarding designers' reliance on direct experiential knowledge and skilled workmanship for material choice, they should increase the knowledge of students and practicing designers through application demonstrations, workshops, etc.

Limitations and research implications

This study fills a gap in research into the indoor built environment through its focus on the determinants of architects' and interior designers' finishing materials selection, and their preferences and prioritizations. This study adopted a novel approach to investigate materials selection through the expert participants' outlook and approach, and materials choices for actual residential projects and a simulated project, applied within the Turkish residential context.

The findings support previous research in architecture and product design and reveal that materials selection is affected by a variety of interrelated factors. Additionally, our study reveals the necessity to consider all three surfaces holistically rather than a single surface, such as flooring, in an interior space.

There are limitations to this study. First, the study is limited to the Turkish context. The emergent categories provide an open-ended framework where themes and sub-themes may vary in different cultural and geographical contexts due to changing criteria, such as material intangible properties, cost, market availability, etc.

A second limitation is the restricted number of architects and interior designers with sufficient relevant experience as participants. Future studies could yield different results by sampling newly graduated designers (who have been exposed to changing pedagogical programs that have introduced sustainability or new materials) across those with extensive experience (where the preference of certain materials based on experience has a major role). Additionally, comparative studies carried out with architects and interior designers, and with professionals in larger firms with different responsibilities and ranging professional expertise (i.e. commercial, residential, or healthcare facility) may yield different results. Likewise, this study did not focus on end-user preferences. Participants composed of users investigating their health and well-being affected by material selections are suggested.

A third limitation concerns the singular space typology where we only cover material preferences and criteria for residential design. Therefore, they need verification for other building types and scales. With the observed importance of project-related determinants, materials choices are likely to vary according to other functions and building types.

This study's comparison of actual and simulated projects provides an exploratory methodology for design decisions in that the researcher can control the design environment in the latter but not the former. A similar research methodology could provide different and rich findings regarding public interiors like shopping malls, hotels, health care, and work settings.

This study lays the grounds for areas of inquiry for materials research specific to the interior design discipline. Rather than an attempt for generalizability, the results hint at potential domains of further investigation, pointing towards emergent issues for finishing material selection that demands attention within the interior design discipline in its own right, an overlooked area in the construction sector.

Acknowledgments

We would like to thank the designers who participated in our research. We would also like to thank the reviewers for their constructive feedback.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Ahmed, S., & El-Sayegh, S. (2022). The challenges of sustainable construction projects delivery–evidence from the UAE. *Architectural Engineering and Design Management*, *19*(3), 299–312.

Akadiri, P. O., Olomolaiye, P. O., & Chinyio, E. A. (2013). Multi-criteria evaluation model for the selection of sustainable materials for building projects. *Automation in Construction*, *30*, 113–125. doi:10.1016/j.autcon.2012.10.004

Al Orabi, M. A. A., & Al-Gahtani, K. S. (2022). A framework of selecting building flooring finishing materials by using building information modeling (BIM). *Advances in Civil Engineering*, *2022*, ID 8556714, 1. doi:10.1155/2022/8556714

Ashby, M. F. (2005). *Materials selection in mechanical design* (3rd ed.). Oxford: Butterworth-Heinemann.

Ashby, M. F., Bréchet, Y. J. M., Cebon, D., & Salvo, L. (2004). Selection strategies for materials and processes. *Materials & Design*, *25*(1), 51–67.

Ashby, M. F., & Johnson, K. (2014). *Materials and design: The art and science of material selection in product design* (3rd ed.). Oxford: Butterworth-Heinemann.

Bako, Z. Z., & Jusan, M. M. (2012). Motivational factors influencing housing interior finish choice and preference. *Procedia - Social and Behavioral Sciences*, *36*, 177–186.

Binggeli, C. (2008). *Materials for interior environments* (1st ed.). Hoboken, NJ: John Wiley & Sons.

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks, CA: Sage.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Budinski, K. G. (1996). *Engineering materials: Properties and selection* (5th ed.). New Jersey: Prentice-Hall.

Criado-Perez, C., Collins, C. G., Jackson, C. J., Oldfield, P., Pollard, B., & Sanders, K. (2020). Beyond an 'informed opinion': Evidence-based practice in the built environment. *Architectural Engineering and Design Management*, *16*(1), 23–40. doi:10.1080/17452007.2019.1617670

Emmitt, S. (2006). Selection and specification of building products: Implications for design managers. *Architectural Engineering and Design Management*, *2*(3), 176–186.

Erman, T., Altay, B., & Altay, C. (2004). Architects and the architectural profession in the Turkish context. *Journal of Architectural Education*, *58*(2), 46–53.

Fernandez, J. (2006). *Material architecture: Emergent materials for innovative buildings and ecological construction*. Amsterdam: Architectural Press.

Fernando, S., Hansen, E., Kozak, R., & Sinha, A. (2018). Organizational cultural compatibility of engineered wood products manufacturers and building specifiers in the Pacific Northwest. *Architectural Engineering and Design Management*, *14*(5), 398–410.

Ferrante, M., Santos, S. F., & de Castro, J. F. R. (2000). Materials selection as an interdisciplinary technical activity: Basic methodology and case studies. *Materials Research*, *3*(2), 1–9.

Fujisaki, W., Tokita, M., & Kariya, K. (2015). Perception of the material properties of wood based on vision, audition, and touch. *Vision Research*, *109*, 185–200.

Godsey, L. (2013). *Interior design materials and specifications*. New York: Fairchild Books.

Grimley, C., & Love, M. (2013). *The interior design reference + specification book*. Beverly, MA: Rockport Publishers.

Harris, D. (2016). Surface finish materials: Considerations for the neonatal intensive care unit (NICU). *Newborn and Infant Nursing Reviews*, *16*(4), 203–207.

Hegger, M., Drexler, H., & Zeumer, M. (2007). *Basics materials*. Basel: Birkhäuser.

Karana, E., Hekkert, P., & Kandachar, P. (2008). Material considerations in product design: A survey on crucial material aspects used by product designers. *Materials & Design*, *29*(6), 1081–1089.

Karana, E., Hekkert, P., & Kandachar, P. (2009). Meanings of materials through sensorial properties and manufacturing processes. *Materials & Design*, *30*(7), 2778–2784.

Karana, E., Hekkert, P., & Kandachar, P. (2010). A tool for meaning -driven materials selection. *Materials & Design*, *31*(6), 2932–2941.

Karana, E., Pedgley, O., Rognoli, V., & Korsunsky, A. (2015). Emerging material experiences. *Materials & Design*, *90*, 1248–1250.

Kicklighter, C. E., Baird, R. J., & Kicklighter, J. C. (1990). *Architecture: Residential drawing and design*. South Holland, IL: Goodheart-Willcox.

Lee, S., Kwon, G., Joo, J., Kim, J. T., & Kim, S. (2012). A finish material management system for indoor air quality of apartment buildings (FinIAQ). *Energy and Buildings*, *46*, 68–79.

Lindbeck, J. R. (1995). *Product design and manufacture*. New Jersey: Simon and Schuster Company.

Ljungberg, L. Y., & Edwards, K. L. (2003). Design, materials selection and marketing of successful products. *Materials & Design*, *24*(7), 519–529.

Mangonon, P. L. (1999). *The principles of material selection for engineering design*. New Jersey: Prentice- Hall.

Markström, E., Bystedt, A., Fredriksson, M., & Sandberg, D. (2016). Use of bio-based building materials: Perceptions of Swedish Architects and Contractors. *New Horizons for the Forest Products Industry : 70th Forest Products Society International Convention. Presented at the Forest Products Society International Convention : 26/06/2016 - 29/06/2016. Retrieved from* http://ltu.diva-portal.org/smash/get/diva2:1001602/FULLTEXT01.pdf.

Peat, M. (2009). Promotion of materials and products with sustainable credentials. *Architectural Engineering and Design Management*, *5*(1-2), 46–52.

Rashdan, W., & Ashour, A. F. (2017). Wit transactions on ecology and the environment. *WIT Transactions on Ecology and the Environment*, *1*, 311–322. doi:10.2495/SC170271

Rohde, L., Larsen, T. S., Jensen, R. L., & Larsen, O. K. (2020). Framing holistic indoor environment: Definitions of comfort, health and well-being. *Indoor and Built Environment*, *29*(8), 1118–1136.

Singer, H., & Özşahin, Ş. (2021). Prioritization of laminate flooring selection criteria from experts' perspectives: A spherical fuzzy AHP-based model. *Architectural and Engineering Design Management*, doi:10.1080/17452007.2021.1956421

Siva, J. P. S., & London, K. (2011). Investigating the role of client learning for successful architect–client relationships on private single dwelling projects. *Architectural Engineering and Design Management*, *7*(3), 177–189.

Sönmez, E., & Tavşan, F. (2018). Relating material selection and sustainability in design. *Open House International*, *43*(2), 28–32. doi:10.1108/OHI-02-2018-B0005

Tas, E., Yaman, H., & Tanacan, L. (2008). A building material evaluation and selection model for the Turkish construction sector. *Engineering, Construction and Architectural Management*, *15*(2), 149–163.

Tonetto, L. M., Brust-Renck, P. G., Ruecker, S., & Pacheco, D. A. J. (2021). Differences in thinking styles across professionals with different academic backgrounds when developing a product. *Architectural Engineering and Design Management*, *17*, 3–16. doi:10.1080/17452007.2020.1801376

van Kesteren, I. E. H., Stappers, P. J., & de Bruijn, J. C. M. (2007). Materials in product selection: Tools for including user-interaction aspects in materials selection. *International Journal of Design*, *1*(3), 41–55.

Wastiels, L. (2010). *Mapping material experience in architecture characterization of material warmth* [Unpublished doctoral dissertation]. Vrije Universiteit Brussel.

Wastiels, L., Schifferstein, H. N. J., Heylighen, A., & Wouters, I. (2012). Relating material experience to technical parameters: A case study on visual and tactile warmth perception of indoor wall materials. *Building and Environment*, *49*, 359–367.

Wastiels, L., & Wouters, I. (2012). Architects' considerations while selecting materials. *Materials & Design*, *34*, 584–593.