Key performance indicators for measuring and evaluating users' sensory perceptions and behaviors in learning spaces in higher design education

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Abstract

The research aims to develop a comprehensive list of key performance indicators (KPIs) that can be employed by designers and businesses in determining the sensory performance of learning spaces, particularly in higher education institutions (HEIs) of design learning. It answers the question of how sense-based performance in learning spaces could be understood, measured, and evaluated and how the field of interior design could create tools for measuring and customizing students' sensory experiences in learning spaces. The research fills the gap created by the non-existence of comprehensive research that identifies a unique set of KPIs for learning spaces based on sensorial metrics in interior space evaluation studies that have sought to identify a set of KPIs to measure the performance of learning spaces. The importance of the research would be manifested in the strong connection between the performances of research and teaching spaces and the sensorial performances of those who use them. A four-phase mixed-methods research (MMR) methodology is employed in the study. Each phase is chronologically arranged, encompassing field research and experimental research, with Politecnico di Milano (PoliMI) design school as a field of experiment. The research is expected to provide guidelines for designing and managing the sensory performance of learning environments. Therefore, potential beneficiaries will include interior designers, architects, engineers, contractors, facilities managers, and policymakers in educational establishments. The initial study findings within PoliMI learning community regarding the sensory experiences in various classrooms at the design campus revealed that sight is the most significant sense of all. Furthermore, lighting, ventilation, and acoustics are the most effective interior design elements that have an impact on the sensory performance of the learning space.

Author keywords

Learning Spaces; Sense-based Design; Key Performance Indicators (KPIs); Human Behavior; User Experience

Introduction

Higher education institutions are constructed facilities to host and support academic-related activities, such as teaching, learning, and research. These facilities typically accommodate a variety of faculties with various specializations (A. O. Abisuga et al., 2019). Additionally, they have a range of spaces, including offices, lecture halls, classrooms, open areas, cafeterias, libraries, studios, workshops, and laboratories. The effectiveness of these learning environments affects staff and student behavior, health, and productivity (O. Abisuga et al., 2015, 2016; Leung & Fung, 2005; Vafaeenasab et al., 2015). Therefore, it is essential to understand students' perceptions of their physical learning spaces to meet their needs.

Students engage their five senses—sight, touch, smell, taste, and hearing—to perceive, gather, and analyze data from the learning environment. Each of these senses serves a purpose by collecting data from the environment and relaying it to the brain, which analyzes the information (Kaleem, 2022). When the brain receives information about the environment via perception and cognition, such as light, aesthetic shapes, textures, colors, patterns, acoustics, odors, objects, and furniture, the brain responds with what is known as "spatial behavior" (Mostafa, 2008; Zhang, 2016). Together, these mental processes enable the students to respond to their surroundings, affecting their performance (Kaleem, 2022).

A KPI is a measurement tool used to evaluate and determine the performance of interior spaces (Lavy et al., 2014); however, a thorough literature review indicates that no holistic design KPIs are in place to meet students' sensory performance at higher levels of design education. This study addresses this gap by providing KPIs for measuring and evaluating users' sensory perceptions and behaviors in learning spaces, which are considered a roadmap that designers and businesses can follow and use from the start of the design process, not just during the user experience phase.

This is achieved using a sequential exploratory mixed methods approach, including literature review, field research, and experimental research. First, a thorough literature review is needed to identify potential KPIs specific to the sensory performance of learning spaces. Following this, a qualitative phase was represented in field research, specifically at PoliMI School of Design, the research's experiment field. The third phase is experimental research, which aims to ensure the collected data and test initial KPIs before finally reaching the research outcomes as proposed KPIs.

Literature Review

Although research into the design of learning spaces is receiving more attention (Perks et al., 2016), more needs to be understood about what students consider a high-quality learning

environment (Riley, 2013; Wilson & Cotgrave, 2020). In HEIs, architects, estate/property managers, and teaching staff do most of the research on space design and often make recommendations based on pedagogical or technical considerations; students' perspectives are rarely explored in this study (Cleveland & Fisher, 2014). This demonstrates the necessity of improving the design of learning spaces and considering sensory preferences during the design process (Patel et al., 2022).

On the other hand, as the number of new learning spaces has increased, academics have begun to look into ways to evaluate these new environments. Many of these methods are discussed in two Australian books where researchers suggest various tactics for figuring out how these novel spaces function (Alterator & Deed, 2018; Imms et al., 2016).

An interior space's condition is measured using KPIs, which are used to identify the space's specific quality and performance (Kim et al., 2005). According to Lavy et al. (2014), it is the key to comprehensively evaluating the effectiveness of a built facility. It systematically measures a space's quality, excellence, and overall performance. Ultimately, it is designed to improve performance in existing places and future initiatives by providing information about what works and does not (Sanni-Anibire & Hassanain, 2015).

However, Cleveland (2016) criticizes current guidelines for learning space evaluation for failing to consider the learning environment's social or human aspects and urges the development of new prospects that directly link pedagogy and space. Similarly, Oliver (2016) notes that existing evaluation models frequently occur in the distinct fields of architecture or education. According to Lavy et al. (2014), choosing a set of KPIs is vital to providing efficient performance evaluation measures for the facility in consideration, especially the sensory performance parameters.

Problem Statement

Though previous research has sought to identify a set of KPIs to measure the performance of learning spaces, comprehensive research that identifies a unique set of KPIs based on sensory metrics still needs to be made available in interior space evaluation studies.

This gap has been visually illustrated through an interdisciplinary research map showing the interconnected disciplines covered during the literature review, as shown in figure 1. Design, social science, and neuroscience are the three main disciplines represented on the map. Several fields have been investigated in each discipline, such as interior design, performance-driven design, and sense-based design under the design discipline; psychology, sociology, and anthropology under social science; and cognitive neuroscience under neuroscience. In each field, a group of areas collectively reflect it from the perspective of the study scope. The goal of the map is not only to show the corresponding fields and areas in the realm of the research but also the disconnected ones, which form the research's central gap. A disconnection between performance-driven design, learning space design, and sensorial design has been revealed, depicted in red lines, supporting the necessity for KPIs for designing and evaluating the sensory experience in learning spaces of HEIs.

Figure 1. Positioning map showing the connected and disconnected parameters in the scope of the research. Source: figure created by the author

Outline of Objectives

The study investigates the connection between the physical learning environment and sense-based design. Therefore, the fundamental goal is to create KPIs for measuring and assessing users' sensory perceptions and behaviors in higher education learning spaces. These KPIs are considered a tried-and-true methodology that designers should follow both academically and professionally. Sub-objectives are set to achieve the research's primary goal, which includes identifying students' sensory needs and preferences, defining sensory performance criteria that have a strong and significant relationship with the physical learning space, and understanding which design elements and strategies best meet these sensory needs to positively influence behavior and impact students' learning, educational performance, individual, and social well-being.

Research Questions

By answering the following research questions, this study fills a void in the literature on how to design learning spaces using KPIs for measuring users' sense-based performance. The research's main question is how the interior design field could develop KPIs for measuring and customizing the experience of the senses in learning spaces. Sub-questions are also developed, including:

1. What are human behavior's sensorial qualities that should be measured in learning spaces?
2. How could those qualities be measured? Who can measure it? What are the evaluation criteria?
3. What could interior design KPIs be created based on those measurements? How could applying it affect the involvement of the human body in the experience of learning space?
4. How can designers and companies use/follow those KPIs to design learning spaces?
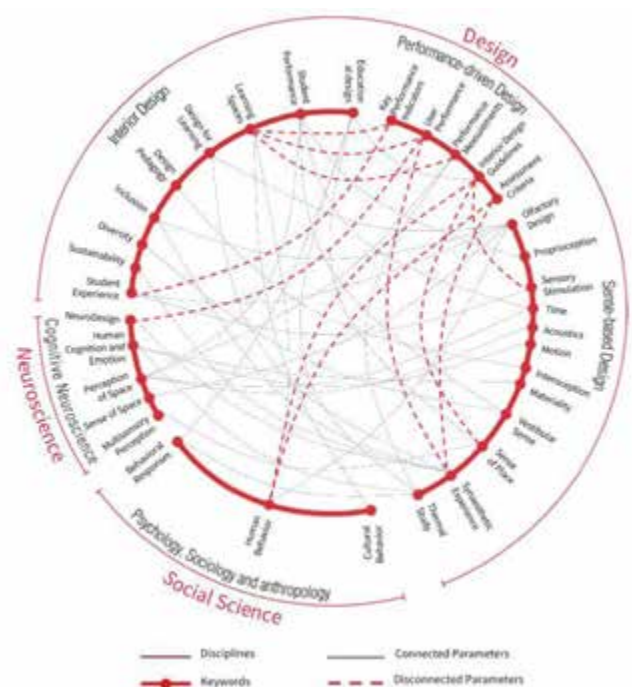

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Research Methodology

A mixed-methods approach has been adopted to achieve the study's desired objectives. It is defined as research in which the researcher collects and analyzes data, integrates the findings, and draws inferences by interweaving qualitative and quantitative data so that research issues are meaningfully explained (Creswell & Piano Clark, 2007; Tashakkori & Creswell, 2007). It enables researchers to answer research questions with sufficient depth and breadth (Enosh et al., 2015), integrating post-positivism and interpretivism frameworks (Molina-Azorin & Fetters, 2016).

Subsequently, the research employs a four-phase approach arranged chronically, as shown in figure 2:

» Phase 1: Literature Review
It consists of the following three stages: collating previous publications to gather a broad list of an initial set of unique KPIs relevant to the sensory performance of universities' learning spaces; Following this, previous studies and results will be categorized into relevant groups before being analyzed by excluding redundant KPIs and ensuring a set of specific and measurable KPIs.

» Phase 2: Field Research
A qualitative study is adopted, aiming to understand and mentor the social behavior of groups of students and educators, particularly at PoliMI, by observing and interacting with others in their natural settings (Queirós et al., 2017) under different sensory variables. Therefore, it includes direct observation, participant observation, and qualitative interviews with academics and professional experts (architects and building designers).

» Intersected Phase
Initial KPIs are developed during this phase using observation and statistical analysis methods.

» Phase 3: Experimental Research
The third phase is experimental research, which fundamentally relies on an appropriate hypothesis test to determine whether the collected data is statistically significant and to ensure the indicators' inclusion, validation, and clarity.

» Phase 4: Interpreting Results
It represents research outcomes as proposed KPIs to be followed and used academically and professionally.
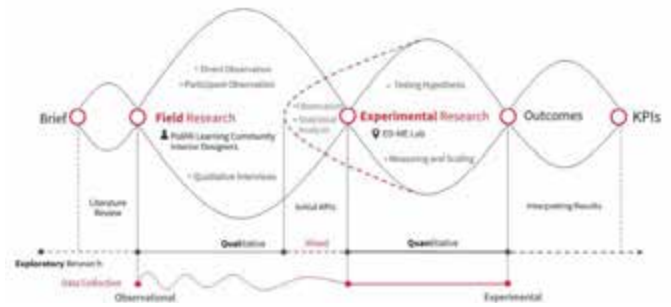

Figure 2. Research methodology phases arranged in a chronological order. Source: figure created by the author

Conclusion

The main essence of the current research is to support designers and companies in the interior design field with a comprehensive set of KPIs unique to the design, evaluation, and measurement of learning spaces in higher design education. The key to achieving this goal is to understand the sensory characteristics of human behavior in learning spaces to be measured, by whom, and with what criteria. Additionally, the method by which designers can use these KPIs for existing and future design projects The study adopts a mixed-methods approach to collect, analyze, and test data, providing the intended results. It started with a literature review consisting of collating previous publications, grouping previous studies and results, and analyzing the previous studies' findings. According to the expected outcomes of the ongoing research, measuring and assessing the performance of the learning spaces of HEIs from a sensory perspective will be guided by the targeted KPIs. As a result, the guidelines enable stakeholders in higher education to understand the needs of their community by actively participating in the development of more sense-based design solutions through a systematic framework. The first round of research findings inside the PoliMI learning community on the sensory encounters in different classrooms at the design campus showed that sight is the core sense. In addition, a learning space's sensory performance is most significantly influenced by lighting, ventilation, and acoustics, which are also the most efficient interior design components.

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