The Effects of Developing Information Technologies on 21st Century Library Architecture

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Abstract
Changes began taking place in the storage, transmission and production of information as Information and Communications Technology started to develop from the mid-20th century onwards. Said changes in the field of information have affected the sources of information, and while altering people's habits of acquiring information, they have presented a new vision with new roles for libraries. This situation required libraries to be reinterpreted with design criteria that affect the function and architectural formation in order to adapt to the new roles. In this study, it is aimed to examine the new design criteria on how developments in Information and Communication Technologies affect the function and architectural formation of 21st century libraries and how they differentiate them from traditional libraries. Within the scope of the study, the functional and architectural design features of three next-generation library buildings selected from different countries were analyzed within the scope of a set of new design criteria. As a result of the research, it has been seen that the 21st century libraries present a new vision with integrated information technologies and architectures as per new design criteria. It has been determined this vision reflects a user-oriented design product that supports social, educational learning and teaching models and makes positive contributions to urban life with its new iconic architectures.
Keywords: Information and Communication Technology; Library; Library Architecture; 21st Century Libraries.

1. Introduction

While technology is being developed with the knowledge that exists in all areas of life and can be produced and developed continuously, the use of technology is also realized with knowledge (İspir & Torlak, 2018). The continuous interaction between technology and information has led to changes and transformations in the information paradigm as a result of developing technology. Changes began taking place in the storage, transmission and production of information as Information and Communications Technology started to develop from the mid-20th century onwards. (Sirel, 2021). In this context, the research question is "How should library architecture adapt to the changes created by the developing Information and Communications Technology in the 21st century?" That's because, according to Edwards (2002), Information and Communications Technology has changed the balance of functionality of libraries and made them a public institution that provides more professional services. Therefore, it is crucial to investigate how the changes occuring as a result of Information and Communications Technology should be adapted to libraries, in order to ensure institutional continuity for the information resources of libraries and society.

Regarding studies conducted on the subject in his paper entitled *New Aspects of Library Design* (2006), Hohmann emphasized that libraries need replanning principles to meet the evolving digital revolution and user needs. The main design principles were examined by taking into account current trends seen in the Dresden and Göttingen State and University Library, the Seattle Public Library and the Idea Stores in London. As a result of said study, it was noticed that new planning principles of library buildings and spaces were evaluated as access and orientation, unique space, comfort, communication and sustainability. In his paper entitled *Emerging Initiatives in Library Management Systems* (2009), Haravu discussed changes in user expectations and information scanning behavior depending on the effect of Information and Communications Technology on library management systems. In their paper entitled *Spatial Effects of "Information Technologies" and "Sustainable Architecture" Approaches on "New Library Architecture"* (2015), Moza and Tokman examined the variable learning styles as a result of information technology and the need to renew learning spaces.

As a priority, the theoretical framework related to the function and architectural formation of libraries from past to present has been revealed in this study. A general evaluation was made in the resulting theoretical framework, and new design criteria affecting the function and architectural formation of the libraries were determined. The identified criteria were examined with the selected international specimen library buildings and the findings were revealed. As a result of the findings obtained, an evaluation was made regarding the innovative vision of the 21st century libraries. It has been been revealed that new roles of libraries, which are also cultural institutions, include

supporting lifelong learning, revitalizing the city and community where they are located as well as making positive contributions to urban life.

2. Theoretical Background
2.1. Libraries as Information Centers and Their Architectural Features

Libraries of Antiquity: Subsequent to when writing was first invented around 3500 BCE, archive/library rooms established to store information resources began with the Sumerians and continued with the Assyrian-Babylonian and Hittite civilizations (Lerner, 2007; Odabaş and Akkaya, 2020). The Egyptians stored their information resources in the library of the Alexandria Museum, which included an archive chamber, museum, botanical garden, observatory, and anatomy room (Cited from MacLeod, Odabaş & Akkaya, 2020). Some archaeologists and researchers are of the opinion that the library was situated as an administrative section within the Alexandria Museum (Lerner, 2007). As for the ancient Greek civilization's Pergamon Library, which was comprised of a series of rooms in the city acropolis, the information resources were placed in a large hall with wooden shelves in the wall niches. Three small chambers on the side were used as reading rooms surrounded by bookshelves as well as a study room for the preparation of written scrolls (Lerner, 2007). The Roman civilization built the Library of Celcius in the town square. The library was designed with three niches in the north and south walls and four niches on the west walls, whereas a two-storey high gallery space was obtained with the niches. When the niches were not enough, a second floor was built, whereby there are historians who believe a two-storey gallery was erected in front of the niche to access this floor. Thus, a three-story high library with two galleries had been created (Yıldız, 1985).

Medieval Libraries: In this period when religion was first and foremost, a typical monastery library was comprised of a rectangular chamber with a high domed ceiling, three or four times its width, with large high windows. Pieces of parchment paper, which started to take the form of a book, were chained and arranged in three different shelf systems. First, books were chained to the curved tabletops by the windows. Later, bookcases with shelves on both sides were used. There was a table-height surface between the shelf compartments. These surfaces were hinged to access the lower chests or additional shelves. Manuscripts were read at both rack systems, sometimes either by standing up or sitting on a bench. Finally, shelves or bookcases were positioned in wall niches. Thus, more books were arranged with the wall system and reading tables were located in the center of the room (Lerner, 2007).

Renaissance and Reform Age Libraries: Johannes Gutenberg's invention of the printing press in the second half of the 15th century made it easier to produce books, rendering a vast increase in the number of books to be read (Dalkıran, 2013). Bookcases and readers in Renaissance libraries were the main elements that played a role in determining the indoor layout and lighting. For readers, there was usually a special armchair or table placed next to a bay window or flat window (Edwards, 2002). Positioned in the middle of the building, reading rooms constituted the main gathering place (Tercan, 2010).

Industrial Age Libraries: The first original specimens of the emergence of libraries as a building typology were seen in the 18th century. Typical library architecture of this century was a reading hall with a circular layout, and domed and deaf walls. A dome covered the reading room and halls, providing illumination via window openings. Bookcases were positioned along the surface of the deaf walls. Accessed via a slight hump above street level, the semi-buried basement of the library building was utilized as storage (Edwards, 2002). In this period, when 'public' libraries as we know them today began to emerge, museums and libraries were generally designed as part of the same building until the 19th century. The characteristic library architecture of the 18th century continued to be incorporated until the 20th century (Tercan, 2010).

Modern Period Libraries: The function and architecture of libraries witnessed significant changes in the 1930s. The open shelf system, which began to be utilized at this time, was effective in shaping the library area (Dahlkild, 2011). Reading rooms were turned into foyers and library entrances that ensured communication between staff and users (Edwards, 2002). The monumental effect, strict geometric form as well as the dome cover over the reading room were abandoned, which resulted in a flexible architectural formation that allowed for more fluid spaces (Tercan, 2010). When library buildings of the Modern Era are examined, it's seen that book checkout units, subject shelves, study rooms, offices, spaces for children, conference rooms, exhibition areas have all been added to the functional program.

Libraries of the Islamic World: Libraries were generally comprised of a domed section and a narrow and a long corridor in the early Islamic world. There were ornate, wooden-covered bookcases in the rooms around the corridor as well as on the walls of the domed section (Baysal, 1991). Subsequent to their conversion to Islam, the Turks established palace and madrasah (university) libraries (Cunbur, 1963). Libraries continued to be founded in madrasahs, lodges and mosques of the Ottoman Empire (Cunbur, 1963; Baysal, 1987, 1991) after the conquest of Istanbul. The first public library, *Kütüphane -i Umumi* (Beyazit State Library), was established by the state in 1882. In 1908, the idea of a 'National Library' was tabled for discussion whereas national libraries were established in

many cities around Turkey (Baysal, 1991). Turkish Libraries of the Republic Period, on the other hand, began to be set up as university, public, national, private and children's libraries in many different cities throughout the country.

2.2. Conceptual Transformation in Information Acquisition and Digitalization of Libraries

Throughout history, there has been a need to record information produced and developed in all areas of life for purposes of storage/protection, as well as the transfer and utilization in the future. After the invention of writing, information written in its most known forms (clay tablets, papyrus and parchment rolls) in Antiquity, continued with printed books after the developments in paper and printing. Graphic resources (photographs, maps, etc.) as well as audio/visual resources (records, cassettes, microfilm, etc.) that emerged as technology has progressed have become new tools in which information is stored and transferred along with printed resources (Dalkıran, 2013). Nevertheless, countless changes have occurred in the field of information since the second half of the 20th century, with Information and Communication Technologies (BIT).

- Librarians commenced the integration of bibliographic information of the collections of each library into the MARC (Machine Readable Cataloging) data standard between 1960 and 1970 (Haravu, 2009).
- Access to inter-library catalog information was provided by librarians via OPAC (Online Public Access Catalog) technology as a result of the rapid spread of the Internet between the 1970s and the 1990s (Haravu, 2009).
- With the development of optical disc technology in the 1980s, information resources were transferred to CD-Rom, whereby users checked out CD-Roms from the librarian to access resources via the help of computers (Dalkıran, 2013).
- As a result of the Internet's widespread use in social life along with steadily improving Information and Communication Technologies, individuals began to access information outside the library after the 1990s.

The 'Digital Library' concept emerged with the transfer of library information resources to digital media and the occasional production of information in digital media (Cleveland, 1998). Being able to access digital information from anywhere, growing up with technology or establishing a relationship has brought about the creation of 'digital natives' and 'digital immigrants' (Prensky, 2001). These so-called digital natives/immigrants began getting involved in a number of activities such as entertainment, free communication, shopping, etc. in the digital environment, thus moving away from social environments. At this juncture, the concept of a 'third space' (Cited by Demir, 2017), defined by the American urban sociologist Ray Oldenburg (1999) for libraries, initiated the contact of libraries with urban culture as public spaces providing opportunities for socialization.

The International Federation of Library Associations' (IFLA) *Multicultural Communities: Guidelines for Library Service* (Pestell et al., 2009) defined three new roles for libraries. As *learning centers*, libraries need to encourage learning by providing materials and services necessary for everyone. As *cultural centers*, libraries need to preserve and present materials and collections from local and different cultures. As *information centers*, libraries need to produce, store and make accessible, as well as transfer all kinds of information in a multi-cultural community (Pestell et al., 2009). So, it's these new roles that have created an opportunity for libraries to renew and adapt to developments.

2.3. Innovative Libraries of the 21st Century and New Design Principles

Libraries need to be innovative in order to sustain their institutional existence and present their new roles to the users. Alaca (2018) stresses that, amongst the innovative models developed so far, an 'outwardly innovative model' should be adopted in order to get familiar with the needs of the outside and provide services in accordance with its ideas. What is meant here is 'external users.' Considering different user opinions in order to become innovative in libraries is one of the crucial beginnings for innovative library design. In this regard;

Architect Harry Faulkner-Brown (1987) stressed that a successful library design should be flexible, compact in order to keep distances as short as possible, accessible, expandable, diverse, organized, comfortable, stable environment with invariably comfortable conditions, safe and economical, not to mention maximum service at a minimum cost.

Architect Steven Foote (1995) emphasized that print and electronic resources should be together, the neighborhoods between venues should be fluidly designed and the reader and staff need to be brought together.

Academician Brian Edwards (2002) mentioned that in addition to the ten basic principles that Harry Faulkner-Brown laid down for successful library designs, they should be sustainable and spirit invigorating as well.

Library user Bernhard Fabian (2002) stated that the most important thing in libraries is the effect of the reading space on the reader. That's because the act of reading is a psychological process and the reader should be able to control his external environment whenever he needs to.

Director of Library and Learning Services, Andrew McDonald (2006) stated that a nice library should be functional, adaptable, accessible, diverse, interactive, convenient, environmentally friendly and safe, efficient, suitable for information technology, while having powerful spaces that are inspirational.

Designer Lori Gee (2006) emphasized that the learning space needs to be healthy, stimulating, adaptable by balancing community and solitude.

According to *Academician Nancy Van Note Chism (*2006), a learning space should have flexibility, comfort, sensory stimulation, technology support, centrality, studio classroom, solution partners/collaboration, live & learn spaces and corridor niches.

Architect Moshe Safdie stressed in a public Q & A session that while designing a library, a fine program can be made based on the attributes and needs of the city (City of Boise, 2018).

It is seen that the opinions of different users for innovative libraries have been directly and indirectly influential in the creation of '**new design criteria**' for next-generation libraries and learning centers of the 21st century. The aforementioned 'new design criteria' are provided in brief below.

Urban Location and Accessibility: In serving important roles in the realization of common life in the community, libraries need to be located at a spot that can be easily accessed by everyone, including the physically challenged. Paths to the library should be legible and result in a memorable stay. Thus, location/place psychology should be considered together with transportation (Edwards, 2002). Recently, many new libraries have been situated in high-traffic areas, further enhancing interaction between the library and community, while supporting the retail mix (Worpole, 2013).

Visibility, Aesthetics, Image: With their new roles, libraries should make their presence felt in the urban environment with their architectural formation, by becoming the symbol of a new kind of environment at the hub of urban life and culture (Worpole, 2013). Libraries need to attract the community with their architectural form. With a wide, transparent entrance facade, users should be able to see inside the library and feel invited and safe (Khan, 2009).

Offering Different Activities: The role of the learning center has brought about the necessity of different learning environments for everyone in libraries. For instance, the concept of 'third space,' such as digital labs, computer areas, training classrooms or labs, makerspace areas, etc. highlights the importance of socio-cultural spaces in libraries. For instance, According to Worpole (2013), libraries should offer performance spaces like exhibition areas, multi-purpose halls, auditoriums, seating areas, etc. and create meeting spaces for live events such as book signing tours, children's storytelling sessions, etc.

Indoor Access and Routing: Since libraries are multi-functional and complex, circulation should be natural and instructive. Once inside, the user should be provided a place for reflection or overview of the indoor layout (Edwards, 2002). Circulation should be easily monitored and vertical circulation should be visible. The effect of control areas in circulation should be soft and information boards and flexible usage areas should be positioned in these areas (Khan, 2009, Amen & Nia, 2020). A space in the library should evoke the next space and thus an instinctive orientation should be provided (Worpole, 2013).

Space Organization: While planning the neighborhoods between the spaces, it should be established with the relationship of adjacency. Because sometimes it may require decent visual communication from one space to another, sometimes a space may need to be visually or acoustically isolated, sometimes one space may require convenient access to the other neighboring space, while it may require complete separation from the other (Khan, 2009). Khan (2009) groups this situation briefly as follows;

- *Positive Adjacency*, spaces are directly related.
- *Neutral Adjacency,* spaces have no common relation.
- *Negative Adjacency*, spaces must be separated.

Horizontal placement is as important in space organization as it is in vertical placement. According to Foote (1995), the neighborhoods between floors should be fluid and a continuity of relationship should be provided between services on different floors.

Access to Collections: Along with Information and Communications Technology, the library collection is divided into two groups, digital and non-digital resources. Both types of collections may require different technical demands and attributes. For instance, computer space for digital resources and another space for printed resources. The important thing is to include collections of local and different cultures in libraries so that everyone can access various resources.

Learning Processes: Many different people have various desires and ways of working in their knowledge/learning processes. While some people don't wish to be disturbed in order to maintain concentration while learning, others enjoy learning together with different individuals in more comfortable and flexible environments. The important thing is that there should be areas in the library that support both individual learning and learning by doing together in order to meet different requests.

Sustainability: Libraries need to give a set of messages to the environment by displaying their architectural formations and sustainability practices in the most appropriate way within the scope of the service they provide (Edwards, 2011). Sustainability and environmental protection policies on a universal scale are handled in three different dimensions; 'Economic,' 'Social' and 'Environmental.'(Aziz Amen,2022)

Economic Dimension; To ensure sustainability by avoiding sectoral imbalances produced in order to ensure continuity in the use of scarce resources and harming this production, and by managing debts under appropriate conditions (Tıraş, 2012). According to the Urban Libraries Council (2010), libraries are the best institutions to create brainpower, which is the material unit of success in the 21st century. From this aspect, libraries play a role in achieving economic development and welfare.

Social Dimension; Every individual needs to benefit from social services such as education and health on equal terms by putting people at the center (Tıraş, 2012). According to the Urban Libraries Council (2010), library resources should be accessible to everyone.

Environmental Dimension; Aims to use renewable resources by protecting the resources in the ecosystem and the balance between them (Tıraş, 2012). According to the Urban Libraries Council (2010), the community should be included in environmental sustainability issues with sustainable architectural design practices.

Smart-Comfortable Interior Elements: Libraries should have various kinds of indoor elements for many reasons such as function, collection types, and user diversity (Odabaş & Akkaya, 2020). Table and seating elements can be examined in separate groups with different sizes, types, textures and materials, mainly collection storage, transportation and access tools (Odabaş & Akkaya, 2020). However, the important thing is that these elements should be of such a variety that will provide comfort conditions for everyone (children, adults, elderly, disabled, etc.).

Spatial Impact Quality: Libraries should be spaces that provide comfort conditions that meet both current and anticipated user needs. Comfort conditions can be examined in three groups as Visual, Acoustic and Climatic Comfort;

Visual Comfort; lighting is important in ensuring harmony with color, texture and material components. That's because all the components that affect the indoor design will directly affect the performance of the library users with psychological factors. When different components are used together, the ambiance in the space will change.

Acoustic Comfort; Libraries are comprised of places where there is sound and where silence is desired. Therefore, acoustic comfort should be considered in the architectural design process (Odabaş & Akkaya, 2020).

Climatic Comfort; Climatic comfort levels are different for library usage areas and collection materials. For instance, it is different in general usage areas with appropriate temperature and humidity adjustments for the preservation of rare artefacts and important documents without deformation (Odabaş & Akkaya, 2020). Appropriate climatic comfort analysis should be made for each space.

3. Case Study

3.1. Materials and Research Method

The materials of this study are next-generation library buildings. Data collection and analysis method was used in the research. Three next-generation library buildings, namely Sendai Mediatheque, Library of Birmingham and Dokk1 Library, have been selected as examples in order to better explain how the 'new design criteria' determined as a result of literature readings are applied within the scope of the study.

Specimen library buildings are determined by the features of being built in the 21st century, having features that distinguish them from traditional libraries, providing maximum diversity, and being public libraries with a wide and different user base compared to other library types. Library buildings; theoretical information, visuals and videos were examined and then new design criteria related to the subject were analyzed through architectural plans and sections. Findings obtained from the analyses were visualized in tables and presented the result of the study.

3.2. Sendai Mediatheque

Designed by architect Toyo Ito, Sendai Mediatheque is a public library opened in 2001 in Sendai, Japan. The Royal Institute of British Architects (RIBA) awarded this library the Royal Gold Medal in 2006 (URL-1).

Before starting the design, Toyo Ito decided that he didn't want to create a room in the library and designed the library with a square plan scheme. Functions are usually separated with indoor elements and curtains. The only mass of the library surrounded by walls is the conference hall and administrative offices located on the fifth floor (Jordana, 2013).

The library uses vertical carrier elements formed by tubular steel elements placed in 13 different support glass tubes that serve as transparent shafts allowing natural light and air to enter the indoor. There are vertical circulation elements inside the widest glass tubes. When the eight movable glass panels used on the ground floor facade are opened, both the integration of the ground floor with the city and natural air and light enter the library.

The south (main) facade is covered with a double-layered glass shell, while the west facade is covered with metal facade elements. Transparent glass, polycarbonate sandblasted glass, and aluminum cladding were used, differently on each floor of the east and north facades (URL-1; Jordana, 2013) (Figure 1). Functions in the library building such as the main entrance, library, information and communication center, exhibition areas and workshops are generally separated between floors. The functional program distribution offered by the library is provided in Table 1.
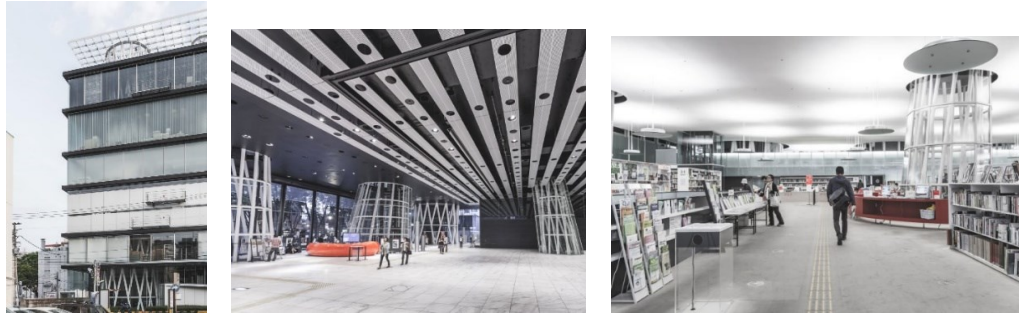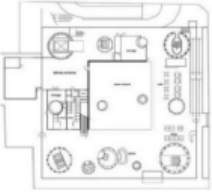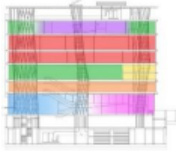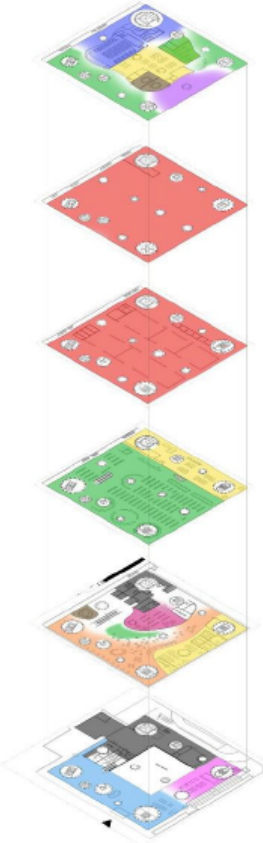

Figure 1. Facade, Entrance Square, Newspaper and Magazine Collection Area [URL-1]

Table 1. Sendai Mediatheque Function Chart [created by the authors using URL-1]

Sendai Mediatheque		
Location: Sendai, Japan Year: 2001 Architect: Toyo Ito	Location	Sendai Mediatheque
Plan and Section	**Plan Chart**	**Layout of Functions by Floors**
Ground Floor Plan Section ■ Entrance / Square ■ Offices (Administrative Units) ■ Storage Space ■ Library ■ Computer Research Area ■ Library for Kids ■ Exhibition space ■ Conference Hall ■ Cafe ■ Meeting Room ■ Open Studio / Workshop Area	Ground Floor | First Floor | Second Floor | Third Floor | Fourth Floor | Fifth floor	**Fifth floor** • Conference Hall and Foyer • Audio-Visual Library • Art and Culture Library (with reading and study areas) • Open Studio / Workshop Areas • Project Room • Offices (Administrative Units) **Third and Fourth Floor** • Exhibition Area and Foyer **Second Floor - Mezzanine** • Local Culture Collection Area **Second Floor** • Librariy (with reading and study areas) • Borrowing / Lending Units • Offices (Administrative Units) **First Floor** • Library for Children • Offices (Administrative Units) • Newspaper and Magazine Collection • Computer Research Area • Talking Room • Meeting room • Storage Space **Ground Floor** • Main Entrance / Square • Cafe • Sales Area (Bookstore) • Delivery Entry and Warehouse

Compatibility of the Sendai Mediatheque Library with New Design Criteria is as follows:

Urban Location and Accessibility: Surrounded by business centers and high-rise apartments, the library building is located on a tree-lined street and provides access for everyone.

Visibility, Aesthetics, Image: The library building is in harmony with the high-rise buildings in the vicinity with its cubic volume, but is distinguished by its transparency. The transparent design integrating the library and public space is a clear symbol of knowledge, learning and sociability.

Offering Different Activities: In addition to the 'information' and 'learning' spaces open to everyone, there are computer technology areas, exhibition areas for socio-cultural interaction, a conference hall and a workshop area in the library.

Indoor Access and Routing: In its open plan design, routing is provided in the circulation with the indoor elements. The circulation elements positioned within the glass column tubes can be grasped in the space at first glance. The three raised yellow lines on the floor are a means of orientation for the visually impaired.

Space Organization: The library building functions are separated according to the floor, namely the main entrance, library, information and communications center, exhibition areas and workshops. The spatial relationship between similar needs and functions has been analyzed within the same floor.

Access to Collections: Various library collections placed on the first, second and fifth floors with different functional areas are made available to the user as open shelves.

Learning Processes: Reading areas, meeting rooms and open workshop areas in the library are environments that support both individual and collaborative learning.

Sustainability: The social and economic dimension of sustainability is supported by education programs for everyone, providing public spaces amidst business centers and apartments, providing internet and technology to the user in the library building that is accessible and safe for everyone, and a myriad of service and activity areas along with education. The environmental dimension of sustainability is supported by various facade designs in its architecture, ensuring the climatic balance in the interior and being located in the city center.

Smart-Comfortable Interior Elements: A variety of interior elements have been provided with seating elements, desks and shelf arrangements of different sizes and shapes for different collection types in the library.

Spatial Impact Quality: In general, visual comfort is highlighted, using white on the flooring and walls and various colors in the indoor elements. Nevertheless, the separation of functions with curtains in some places weakens the visual effect. While paying attention to acoustic comfort with the balanced distribution of sound and silent functions between floors and double-glazed facades, climatic comfort is provided through its structural techniques.

3.3. Library of Birmingham

Designed by the Mecanoo architecture office, the Library of Birmingham is a public institution that opened in Birmingham, U.K. in 2013. The library received the BREEAM Certificate of 'Excellence' in 2013 as well as the 2014 RIBA (Royal Institute of British Architects) National Award (Mecanoo, 2022). Comprised of four different prismatic volumes, the library building intersects vertically at different points. The intersecting volumes form terraces in a cantilevered building mass.

Natural light and air enters the library from a central point via the chimney effect of the circular Book Rotunda in the center of the library (URL-2). The circular Underground Outdoor Performance Area in the library square provides the basement floor with natural light and air. Acoustic materials are affixed on the ceiling as per the spaces in the library where silence is highly desired or less desired. Curtain walls and double paned glass are used on the facades to hinder street noise from entering the building. Separate measures have been implemented into the walls and floors to dampen out any excessive noise stemming from mechanical ventilation systems, workshop/studio and equipment (URL-2). A foyer links the main entrance of the library to the Repertory Theater, which dates back to 1962. Designed in 1882, the Shakespeare Memorial Room is integrated into the library's attic rotunda (Mecanoo, 2022) (Figure 2). A breakdown of the functional program available at the library is provided in Table 2.
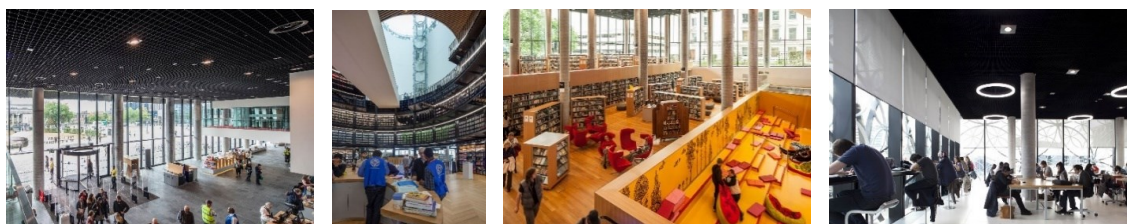

Figure 2. Entrance Square, Book Rotunda, Bookcases and Children's Amphitheater, Study Area [Cited by Harry Cock and Christian Richters, Mecanoo, 2018]

Table 2. Library of Birmingham Function Chart [Mecanoo, 2022; Created by the authors using URL-3]

Library of Birmingham		
Location: Birmingham, United Kingdom **Year:** 2013 **Architect:** Mecanoo Architecture	**Location**	**Library of Birmingham**
Plan and Section	**Plan Chart**	**Layout of Functions by Floors**
Ground Floor Plan **Section** ■ Entrance / Square ■ Offices (Administrative Units) ■ Book Storage ■ Library ■ Library for Children ■ Exhibition space ■ Conference Hall ■ Cafe ■ Meeting room ■ TV Rooms ■ Flexible Sitting Area ■ Underground Outdoor Performance Area ■ Open Research Units ■ Study Rooms	*Seventh Floor | Fourth Floor | Third Floor | Second Floor | First Floor | Ground Floor | Basement Floor*	**Eighth and Ninth Floors** • Shakespeare Memorial Room **Seventh Floor** • Offices (Administrative Units) • Open Terrace **Sixth and Fifth Floor** • Archive and Heritage Collections **Fourth Floor** • Archive and Heritage Collections Open Research Units • Library (Map, Microfilm, Genealogy, etc. Resources) **Third Floor** • Exhibition space • Library and Reading Area (with Sitting Areas) • TV rooms • Open Terrace **Second Floor** • Library and Reading Area (with Sitting Areas) **First Floor** • Library and Reading Area (with Sitting Areas) • Group Rooms • Meeting Rooms **Ground Floor** • Entrance / Square • Cafe and Sales Areas (Bookstore) • Auditorium • Music Library • Weston Research Library **Basement Floor** • Book Storage • Children's Library • Libraries and Reading Areas • Underground Outdoor Performance Area

Compatibility of the Library of Birmingham's with the New Design Criteria is as follows:

Urban Location and Accessibility: A conference center, a concert hall, an ice rink, and a city park are located in the immediate vicinity of the library, which has been situated adjacent to the Birmingham Repertory Theater (REP) since 1962. Situated in close proximity to key focal points, the library offers access to people of all walks of life.

Visibility, Aesthetics, Image: Comprised of four various sized prismatic volumes, the library building is distinguished from other buildings by its glass, gold, black and motif-patterned facade cladding. A functional facade design was created by means of transparent appearance of the main entrance square, opaque motif coatings on the library and management floors, and opaque design of the archives/warehouses.

Offering Different Activities: Rather than a book-oriented building approach, the library structure offers a functional program with socio-cultural functions replete with various education and activity areas.

Indoor Access and Orientation: A central circulation point has been created with the stairs and elevators located in the Book Rotunda of the library building. The panelboards in the interior provide orientation to the users.

Space Organization: While the spaces where user density is higher are placed on the ground and upper/lower floors, spaces not used by the user, such as management units and archives/warehouses are located on the top floors.

Access to Collections: Different collections that appeal to everyone are shared between floors and presented openly to users.

Learning Processes: The study and seating areas, group rooms and meeting rooms found in reading areas support both individual and collaborative work.

Sustainability: Sustainability is economical, social and environmental dimensions are supported with various education and learning programs for everyone, bringing the internet and technology closer to users, being an accessible and safe institution for everyone, benefiting from daylight and natural ventilation, having different facade designs for functional natural lighting, and well as being located in the city center.

Smart-Comfortable Interior Elements: Various seating elements and work areas, as well as a variety of shelf arrangements for different collection materials, diversity and comfort are provided in the library's interior elements.

Spatial Impact Quality: A visual effect suitable for the functions is provided with the color matches of the interior. Acoustic and climatic comfort is provided by the library's architectural formation and technical details.

3.4. Dokk1 Library

Designed by the Schmidt Hammer Lassen architecture office, the Dokk1 Library is a public library that opened in 2015 in Aarhus, Denmark. The library building received the Public Library of the Year Award in 2016 at a ceremony held at the IFLA congress (Schmidt Hammer Lassen Architects, 2022). Raised from the ground up, the library building features a polygonal form. The library's main entrance is via the first floor by accessing the open terrace on the ground floor with a transparent surface. Comprised of light-colored metal coatings, the facade has continuous transparency. Six different skylights found on the roof of the library draw daylight deep into the building (Hapel et al., 2015) (Figure 3).

Certain criteria were taken into consideration so as to ensure the library building complies with the low energy statute of 2015. As it is situated on the seashore, the water's natural effect in the air is utilized to cool the building in summer, whereas a protective measure has been taken against sunlight thanks to the installation of a wide roof plate. Thanks to its compact form, thermal loss has been reduced as much as possible, whereas the use of solar panels, LED lamps, motion and daylight sensors have all been incorporated (Schmidt Hammer Lassen Architects, 2022; Hapel et al, 2015). A breakdown of the functional program offered at the Dokk1 Library is provided in Table 3.
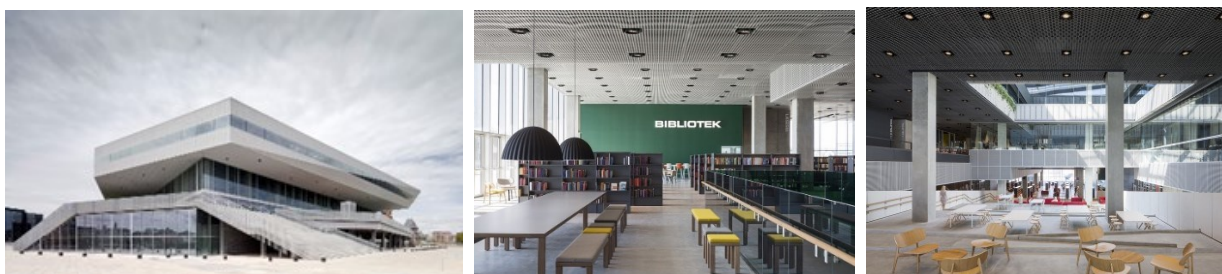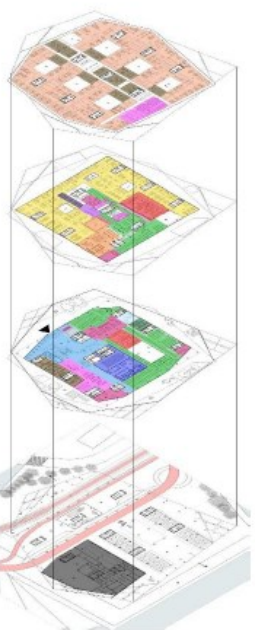

Figure 3. Public Square, Libraries, Media Ramp [Schmidt Hammer Lassen Architects, 2022; URL-4]

Table 3. Dokk1 Library Function Diagram [created by authors using URL-4]

Dokk1 Library		
Location: Aarhus, Denmark Year: 2015 Architect: Schmidt Hammer Lassen	Location	Dokk1 Library
Plan and Section	**Plan Chart**	**Layout of Functions by Floors**
Ground Floor Plan Section		**Third Floor** • Rentable Office Rooms • Meeting Rooms • Cafe / Canteen
■ Entrance / Square ■ Offices ■ Book Separation/Forwarding Units ■ Libraries ■ Areas for Kids ■ Media Ramp ■ Conference Hall ■ Cafe ■ Meeting room ■ Rentable Office Rooms ■ Flexible Seating Area ■ Project Room ■ Transformation Room ■ Play ground ■ Aarhus Historical Archive Room	Third Floor / Second Floor / First Floor / Ground Floor	**Second Floor** • Offices (Administrative Units) • Bookcase (with sitting areas) • Media Ramp • Children's Play Library, Learning Area and Laboratory • Play ground • Aarhus Historical Archive Room **First Floor** • Library (with reading and study rooms) • Transformation Room • Project Room • Media Ramp • Meeting Rooms • Conference Hall (two for adults and children) • Cafe • Flexible Seating Areas • Open Terrace **Ground Floor** • Parking area • Rail Transportation Line • Book Separation/Forwarding Units

Compatibility of the Dokk1 Library with the New Design Criteria is as follows:

Urban Location and Accessibility: The library building is part of a plan to revitalize a former industrial port zone and incorporate the historic port into the city (Hapel et al., 2015). Surrounded by Filmby Aarhus Town Hall, the police department and commercial centers, the library building is situated along the light rail transit line.

Visibility, Aesthetics, Image: With its polygonal form, its ice floe-like appearance over a raised ground distinguishes it from the buildings in the vicinity. The outdoor square and steps in front of the library offer a public space for users.

Offering Different Activities: In addition to the library, reading and study areas, socio-cultural spaces are included and different functions are offered for the users. With office rooms of many different sizes to let, the library building is an indication the library can be used for everyone (e.g. for business meetings).

Indoor Access and Routing: There are circulation elements at many different spots in the library. The library is generally designed with an open plan setup, creating a flexible circulation space between functions. However, the areas where the administrative units are located have been created with a corridor layout. The Media Ramp in this library is not only a social area for users, but also offers a circulation area between the first and second floors, just like an amphitheater comprised of ramps. The panelboards and writing on the floor direct the users to the functions.

Space Organization: In choosing an open plan layout for the relationship between the libraries and the square on the ground floor, a positive adjacency relationship has been established in the continuous functional organization. Vertical building elements partition the administrative units on the second floor of the library from other functions. Finally, more room arrangements were made and special working environments were created on the third floor.

Access to Collections: Along with reading, working and seating areas, a myriad of collection materials is available to users only on the first and second floors.

Learning Processes: The project and learning rooms, open activity areas, rentable office areas or meeting rooms, open study areas found in the library offer spaces that are suitable for individual or collaborative, loud or silent, flexible or serious working processes.

Sustainability: Rental offices, as well as study, project and teaching rooms providing internet and technology support for everyone, being an easily accessible and reliable institution for everyone, having community service counters in the main entrance square to support and serve the personal needs of citizens, the benefitting from the water's natural cooling effect, protection against sunlight with a wide roof plate, the reduction of thermal loss in compact form, the solar panels on the roof, LED lamps, motion and daylight sensors all support the economic, social and environmental dimensions of sustainability.

Smart-Comfortable Interior Elements: Diversity and comfort are provided with various interior seating and study settings, different collection shelf arrangements, as well as furnishings and equipment suitable for function and purpose.

Spatial Impact Quality: Though concrete, wood and metal colors are generally incorporated in interior horizontal and vertical partition elements, a visual effect suitable for functions is achieved by coloring the space with furniture and equipment. Attention has been paid to acoustic comfort by making horizontal partitions and furniture distinctions between functions that require intense sound or silence. Climatic comfort has been provided with the decisions taken for architectural formation.

4. Findings

The 'new design criteria' set forth in the literature section of the study on 21st century next-generation libraries were accepted as the analysis parameters of this study. The Sendai Mediatheque, Library of Birmingham and Dokk1 Library buildings, which are the sample areas of the study were scrutinized over these parameters whereas the following findings were compiled.

- Within the scope of urban location and accessibility criteria, the library buildings in question are amongst the important socio-cultural and commercial structures in their city centers and offer a public space to the citizens. Since they are located in the city center, they are easily accessible by everyone.
- Within the scope of visibility, aesthetics and image criteria, transparent facade design on the main entrance floors of the libraries and facade designs in which transparency and opacity are balanced in accordance with the function are in the forefront of the upper floors. The transparent and original designs of the libraries have highlighted the information spaces. Moreover, these library buildings are integrated with open public space in front of them, thus offering outdoor activity opportunities.
- Within the scope of the criteria for offering different activities, in going beyond traditional library spaces, the computer technology area, workshop areas, meeting rooms, rental offices, project and transformation rooms as information and study spaces have been incoporated in their functional programs. Moreover, a myriad of spaces such as exhibition areas, conference hall, open performance areas, small TV rooms, open terrace areas, amphitheater designs, flexible seating areas and reading/game/activity areas for kids as socio-cultural spaces have begun to be incorporated into 21st century libraries.
- Within the scope of indoor access and orientation criteria, rather than the traditional corridor layout in libraries with generally open plans, circulation areas are created between functions. Control points have been created in the circulation by using flexible, short-term and low-intensity areas in areas with combined functions. Circulation elements are situated at various points at the Sendai Mediatheque and Dokk1 Libraries, and at a central point at the Library of Birmingham. Moreover, panelboards were used as auxiliary elements to provide access and orientation at all three libraries.
- Within the scope of space organization criteria, functions requiring short-term, intense movement and sound are located on the lower floors, while functions requiring long-term silence and concentration are located on the upper floors at all three libraries. Positive and neutral relations were provided, depending on the intensity and duration of use (more or less intense/short-long term) of the functions (educational, social, etc.) and acoustic levels (loud and silent) between the floors.
- Within the scope of access to collections criteria, collections and materials for everyone, from different cultures are presented to the user in a balanced way with reading/study and seating areas.
- Within the scope of the learning processes criterion, open study spaces, meeting rooms, group study rooms and workshops, as well as spaces that support individual, collaborative/cooperative learning processes are offered to the users.

- Within the scope of sustainability criteria, the libraries in question provide the economic dimension of sustainability by offering lifelong learning to all users with their education and training programs and improving their city location. They provide access to library services by everyone, provide digital balance by bringing all users together with computers and technology, are institutionally accessible and reliable, and provide social-cultural sustainability with different education, training and activity programs. Different design strategies such as the form, the chimney effect created by the courtyard in the center and the facade design, solar panels, sustainable lighting elements, which are effective in the architectural formation, support the environmental dimension of sustainability.
- Within the scope of the Smart-Comfortable interior elements criterion of the libraries in question, diversity is provided in interior elements in accordance with different functions and needs. Various interior elements in the reading/study and seating areas offer the users the opportunity to choose, depending on their personal wishes and comfort. With shelf arrangements suitable for different collection materials, the collections are both preserved and presented to the user.
- Within the scope of the spatial effect quality criterion, a balance of visual comfort was achieved in the interior as a result of the matching of colors in the ceiling, wall, floor and indoor elements of the libraries in general. The relationship between acoustic levels in the interior organization and design decisions considered in the architectural formation provided acoustic and climatic comfort in the library.

Findings pertaining to compatibility with the new design criteria of the Sendai Mediatheque, Library of Birmingham and Dokk1 Libraries are summarized in Table 4.

Table 4. Compatibility of 21st century next-generation libraries with 'new design criteria' [Compiled from text readings by authors]

New Design Criteria	Sendai Mediatheque	Library of Birmingham	Dokk1 Library
Urban Location and Accessibility			
• In the city center	✓	✓	✓
• Associated with surrounding buildings	✓	✓	✓
• Access by public transport/private vehicles	✓	✓	✓
• Access for all	✓	✓	✓
Visibility, Aesthetics, Image			
• Iconic architectural formation	✗	✓	✓
• Inviting entrance and square	✓	✓	✓
• Being a symbol	✓	✓	✓
Offering Different Activities			
• Spaces of knowledge and learning	✓	✓	✓
• Socio-cultural spaces	✓	✓	✓
• Spaces for everyone	✓	✓	✓
Indoor Access and Routing			
• Soft control areas	✓	✓	✓
• Routing tools	✓	✓	✓
• Easily monitored circulation	✓	✓	✓
Space Organization			
• Positive adjacency	✓	✓	✓
• Neutral adjacency	✓	✓	✓
• Negative adjacency	✗	✗	✗
Access to Collections			
• Inclusion of different collection materials	✓	✓	✓
• Finding collections for everyone	✓	✓	✓
• Access for all	✓	✓	✓
Learning Processes			
• Self-study learning	✓	✓	✓
• Learning by doing together	✓	✓	✓
Sustainability			
• Economic	✓	✓	✓
• Social	✓	✓	✓
• Environmental	✓	✓	✓
Smart-Comfortable Interior Elements			
• Need and purpose oriented	✓	✓	✓
• Suitable for comfort conditions	✓	✓	✓
• Choices with width satisfying the user	✓	✓	✓
Spatial Impact Quality			
• Visual comfort	✗	✓	✓
• Acoustic comfort	✓	✓	✓
• Climatic comfort	✓	✓	✓

5. Conclusions

Having started out as archive rooms in order to protect, store and transfer information resources to the future, Library buildings have begun to have different purposes and are being totally revamped as a result of the developing Information and Communications Technologies. As a result of the digitization of many of the materials that constitute information resources of libraries, the paradigm shifts in the methods of searching and acquiring information have had an impact on the function and shaping of the libraries. Unlike the old-school library concept, which presents its materials on shelves and in quiet working environments, libraries have now become a place of communication. These circumstances necessitated the redefinition of architectural designs of library buildings, rearranging them under the heading of 'new architectural design criteria,' whereas 'Urban Location and Accessibility,' 'Visibility, Aesthetics, Image,' 'Offering Different Activities,' 'Indoor Access and Routing,' 'Space Organization,' 'Access to Collections,' 'Learning Processes,' 'Sustainability,' 'Smart New Design criteria such as "Comfortable Indoor Elements' and 'Spatial Impact Quality' gained importance in designing new libraries.

In going beyond being mere information centers, 21st century libraries have begun operating as learning and cultural centers. As is seen in the three libraries examined within the framework of this study, 21st century libraries are designed for children, adults, elderly, etc. Thanks to its new functional programs for everyone, they have begun to be designed not only for readers but also for everyone in the urban environment to become everyone's library. Along with their printed and electronic information resources, they are committed to a new library vision that gets the user more involved in 'learning by doing,' provides communication between socio-cultural areas and users, and integrates information and socio-culturalism. In addition to individual developments, this vision that supports lifelong learning includes the richness of creating a more social and collaborative society structure that adopts social learning and interaction. Next-generation libraries have become institutions that revitalize and occasionally support the city and society, both by offering a public space in their communities and by establishing relations with other socio-cultural areas. While beginning to serve all segments of society, libraries have become one of the clear examples of sustainability with their operations and architectural formation. 21st century library buildings differ from traditional library buildings and other cultural institutions by their architectural design strategies that sustain urban life, while developing society and protecting environmental resources.

As a result, as Information and Communications Technologies become more and more integrated into libraries, it is inevitable that next-generation libraries will come to the forefront with both new functions and new architectural formations. In supporting social and educational learning and teaching models, these libraries reflect a user-oriented design product, while making positive contributions to urban life with their iconic architecture.

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