



Emerging Technologies in Academic Libraries: Artificial Intelligence and Big Data

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Abstract

Advancements in information and communication technology have catalyzed developments in all industries globally in the past two decades. In this study, we have addressed the importance of digital technologies, specifically emerging ones, and their implications for digital transformation to achieve a competitive advantage among academic libraries. One of the main objectives of the study is to identify the positive impacts of emerging technologies on academic libraries, as well as identify how academic libraries can invest in emerging technologies to develop library services. The study utilizes the descriptive method. The paper concludes with the importance of data and how to maximize the benefit of big data and restore the structure of collecting big data by regrouping, organizing, and making it available and more comprehensive. The study also sheds light on the digital transformation at King Abdulaziz University, its direction towards enhancing the concept of big data, and its impact on improving services and decision-making.

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1 Introduction

Advancements in information and communication technology have catalyzed developments in all industries, globally, in the past two decades. Despite creating many opportunities, and added diversity in the form of information resources, publishing channels, storage, preservation and retrieval methods, these technologies present several challenges and difficulties for researchers and academic libraries alike [1,2,3].

Libraries are no longer the only source of information for academics and researchers, as the information boom concomitant with the complex transformation in information and communication networks has modified researcher behavior by increasing the likelihood of their use of online digital sources over traditional library systems and resources. Furthermore, online resources offer innovative search and analytic tools that render huge available data sets more accessible and of greater functional value to the researcher, based on contemporary technologies such as machine learning and artificial intelligence (AI). The practice of using online resources is adopted by many researchers [4]. Therefore, libraries and librarians are striving to return to the research and scientific investigation scenario by adapting to and embracing these leading-edge technologies and progressive tools. However, limitations in technical infrastructure, and the volume and diversity of data, make it difficult to integrate and implement such technologies and applications. Procedures to incorporate these resources will consume most of a librarian's time even before the data can be made available to researchers.

Efforts towards digitalization in academic libraries are evident, especially considering the trend towards e-learning and distance learning. The development of technologies such as artificial intelligence, machine learning, statistical analyses of big data and cloud computing, as emerging technologies with their large and promising future that will revolutionize the map of the industry and the economy, generates a necessity for extensive studies to investigate the possibility of applying these technologies to the library's work environment and amenities [4,5,6]. Studies should include the field of services, procedures, and methods of management to produce a comprehensive, user-centered concept that focuses on cognitive intelligence.

In this study, we examine the most advanced digital technologies, with a focus on emerging technologies such as artificial intelligence, machine learning, and big data. We explain some of its key features and applications in the context of digital transformation in academic and research libraries. Furthermore, the study provides a roadmap for how libraries can build their AI-based systems. The aim is to identify opportunities and avoid the threats that some of these technologies may pose to the libraries. Additionally, we discuss how libraries can achieve a renewed competitive advantage by redesigning their services in alignment with current innovation and technology. The possible use of game theory is investigated to reformulate the strategies of libraries and their information structures to overcome internal reservations and become more open towards collaboration and technology adaptations. Finally, the paper reviews the experience of King Abdulaziz University in its digital transformation, its direction towards enhancing the concept of big data, and its impact on improving services and decision-making.

Several institutions have resorted to quickly adopting and activating electronic and technical systems that help them execute their educational programs remotely, and are now witnessing a comprehensive reorganization of their services and internal units in line with new educational practices. Academic libraries are no exception, as they play a vital role in the educational and research system.

This study deals with the most important advanced digital technologies with a focus on some emerging technologies such as artificial intelligence, machine learning, and big data, with an explanation of its main concepts and applications in the context of digital transformation in academic and research libraries.

Furthermore, it tackles how libraries can achieve a renewed competitive advantage to provide better service to their beneficiaries. It considers reformulating the strategies and information structures of libraries with scientific and engineering techniques (game theory) to become more accepting of these technologies and to overcome internal reservations and difficulties with adoption. Accordingly, the issue of the study is formulated to answer the main question, “what is the role of emerging technologies in developing library services?”

The importance of this study includes raising the quality and quantity of the services provided by academic libraries, investing in emerging technologies to enhance the library’s future, designing new library services, methods, and strategies that rely heavily on emerging technologies, and supporting the educational and research process in new ways, enriching the quality of interactive learning and improving the quality of interactions.

This study’s questions are What are the emerging technologies in academic libraries? What is King Abdulaziz University library’s experience in using emerging technologies? How do academic libraries invest in emerging technologies to develop their library services? What proposals and solutions can improve the services of similar academic libraries?

2 Previous Studies

Vijayakumar and Sheshadri [6] examined applications of artificial intelligence in academic libraries such as expert systems, checks, and interactive images. It highlighted the importance of artificial intelligence in academic libraries through multiple elements, the most important of which are advanced learning mechanisms, translation, information structuring, aid in delivery, and robotics to improve learning and scientific analysis. The researchers emphasize that these areas are not separate because, in most cases, several applications contribute to the development of library services. Moreover, the study also indicates that implementing a few artificial intelligence applications enhances the quality of services and thus positively impacts all library services.

Gul et al. [3] investigated the integration of technology into libraries that depend on smart technologies, in terms of their functions, services, and working mechanisms. The study dealt with how to create a smart library and mentioned the most important smart technologies in libraries, including artificial intelligence systems and expert systems, as well as investment in applications such as open data, data mining, social media, and smartphones. Further, the researchers designed a set of models to integrate technologies into building smart libraries, with strategies rely on the functions and roles of the library, and for the competitive services provided by smart libraries, including the provision of alternative services.

Jiang et al. [13] covered how to formulate emerging strategies through the Internet of Things (IoT) and big data, as information is a driving force for economic growth. In addition to breaking traditional development barriers, the researchers considered that standards for the IoT have not yet

matured, as the standards are still overlapping and unclear. Institutions of all kinds, libraries, in particular, lack a unified model, which limits the improvement of the structural organization as well as the development of the Internet of Things. The study emphasized the necessity of combining theory and practice with game theory and its profit function. It concluded with the need to identify the selection mechanisms for the IoT and to discover the practical application of these models through game theory.

On the other hand, Cao et al. [4] reviewed building a smart library and identify the most important modern applications that support the construction of a smart library. The researcher reviewed the differences between the types of smart libraries by analyzing them according to technology, services, and workers. Traditional libraries could become smart libraries by embracing new strategies; attracting advanced technologies to provide new services to their beneficiaries such as data mining, artificial intelligence, expert systems; and most importantly, by training workers to use these technologies. This study is important for library managers and strategic planners who are developing and integrating the infrastructure by providing guidelines, especially for those to move to a smart library.

Hayes [15] explored game theory and how to invest it in libraries by developing a model that helps decision-makers in libraries to improve library services through designing solutions relevant to services and functions in the library; cooperation among decision-makers to solve problems; studying the nature of services and jobs. With several methods to assist decision-makers in libraries in economic and social respects, the most important things are resource sharing, cooperative provisioning, and shared indexes. It also indicated that cooperative procurement and cooperation could be invested in automated services, through game theory, to solve problems, by applied through joint work among decision-makers in libraries based on artificial intelligence systems, through which the policies and rights of all participants are guaranteed. Although game theory has been applied in other fields such as economics and industry, it has not been applied much in libraries. Game theory designs an intelligent mathematical model for libraries governed by its type of service and shared resources, through designing a special strategy for decision-makers.

3 Method

This study relies on reviewing several multi-disciplinary papers, to achieve the objectives of the study. The nature of the study is an extrapolation of a blueprint for academic libraries. By relying on the descriptive approach, which is appropriate to the nature of the study, we review emerging technologies, as well as present King Abdulaziz University library as an example for the implementation of emerging technologies to develop its services.

4 Concept of Emerging Technologies

Emerging technologies, an extension of the concept of advanced technologies, describes a modern technology based on scientific research, or the development of an existing technology, characterized by creativity and rapid development, which is expected to be available within the next five to ten years and usually has significant social or economic impacts [7].

These advanced and emerging technologies offer new opportunities, some of which may be transformed within a brief period into “disruptive technologies” that provide alternative solutions and cause a radical transformation of the economy or industry. These technologies force companies and existing institutions to rethink their operations and make rapid adjustments in their principles and operating mechanisms to compete and ensure their survival [7]. History provides ample evidence, including the stumbling of the paper-based printing industry, especially newspapers, due to technological advancements in Internet services, the speed of data, and the accompanying boom in digital blogging, forcing major international newspapers to either close or switch to becoming electronic newspapers. Likewise, the real estate industry faces a huge obstacle due to the emergence of many digital applications that provide services directly, electronically, and with an innovative business model.

A recent example of disruptive technologies is the emergence of e-sports, which is now changing the sport’s industry. Competitive video games attract millions of viewers and fill the stadiums with audiences. These sports even surpass football. This is because, recently, the sports sector has the most potential for global growth [7].

Technologies such as artificial intelligence and machine learning systems, the Internet of Things, big data, cloud computing, robots, and drones, are still pushing many institutions to amend regulations, laws, and work mechanisms to ensure the provision of an incubator environment for these technologies, to ensure the continuity thereof [4-8].

In the context of educational institutions, especially academic libraries, with the widespread use of the Internet and mobile technology, libraries are no longer the only source of information. Therefore, the current circumstances impose on those interested in evaluating these technologies and the adaptation required thereby. The aim is to identify opportunities and avoid the threats that some of these technologies may pose to the library system and the services it provides.

5 Data-based Technologies

5.1 Big Data

The term big data refers to a growing resource available in a structured or unstructured form, and it is so complex that traditional data management tools cannot store or process it efficiently [9]. Most research focused on ways to combine and integrate big data to improve business designs and service management. To extract valuable and substantial information from these data, effective and fast processing techniques are required. The concept of big data is based on the 5Vs model, summarized as follows [9]:

- **Volume:** The large volume of data is the amount produced or that can be collected and its benefits, increases with the volume of the data.
- **Velocity:** Velocity refers to the speed with which data are generated, collected, and analyzed and is a direct indication of efficiency and effectiveness.
- **Variety:** Variation in the type of evidence is one of the key features of large data, often disorganized and difficult to systematize into a common database, thus greatly escalating the complexity of the storage and analysis processes.
- **Variability or Validity:** This is about ensuring the quality or reliability of the data.

- **Value:** It refers to the ability to transform big data into value or knowledge that can be exploited beneficially.

To research the applications of big data in libraries, we must realize that big data is a broad concept that includes scientific and applied aspects, tools, techniques, and assistance that contribute in their entirety to converting this huge volume of data into useable information and knowledge. These tools include the ability to **collect and filter** large data, **analyze** and process it, and then display it to expedite decision-making. Additionally, these tools need to use related technologies—techniques based on applied mathematical models; therefore, techniques such as data mining or machine learning are always mentioned when introducing the concept of big data. These techniques contribute greatly to extracting hidden data and exploring tacit information. Therefore, we delve into the next section on artificial intelligence and machine learning.

5.2 Artificial Intelligence and Machine Learning

Artificial intelligence or machine intelligence, a more comprehensive concept than big data, is a branch of science that deals with simulating human intelligence in learning and problem-solving and applying it to devices and machines to provide them with the ability to perceive and take measures in achieving specific goals [10]. This is done by engaging machines with their surroundings, without human orders and interference, and without being pre-programmed. The human mind has an immense ability to perceive and analyze data from voices and images and make decisions, but it is limited by the number of tasks that it can perform simultaneously. However, artificial intelligence enables machines to conduct many tasks concurrently with similar ability as the human mind in perception and analysis. Another competitive advantage calculated for AI technology is the ability to learn quickly from data beyond the potential of the human mind. According to reports from McKinsey, the upcoming transformation of industry, due to artificial intelligence, resembles what happened when electricity was invented 100 years ago. Artificial intelligence is expected to generate more than \$13 trillion by 2030, most of it in non-technical sectors such as agriculture, energy, industry, and education [10].

Therefore, the most important research and applications provided by artificial intelligence technologies fall into two broad categories:

5.2.1 Perception

Among the most advanced applications are those that rely on voice recognition, such as Siri, Alexa, and Google Assistant, which have proven their quality and effectiveness for millions of users around the world. For example, Window's Speech Recognition is three times faster than typing on a cellphone. The error rate decreased from 8% to 4% only during the past four years [11]. Applications that rely on image recognition include Facebook and its use of technology to analyze images, identify people and link them to a list of your friends. The same techniques are used in self-driving cars and to identify individuals crossing the street by training the machine with millions of pictures of road intersections, traffic lights, and individuals crossing the street. This uses huge databases specially prepared for training and learning, such as the ImageNet database, which

contain more than 14 million images with more than two thousand image classifications to help developers and researchers design self-learning systems, contribute to reducing the error rate and increase the effectiveness of the machine [11]. On cellphone cameras, some applications recognize the type and name of any bird that is being photographed. Furthermore, image recognition is used in medical applications and examination methods to discover some diseases.

5.2.2 Cognition

The second category of artificial intelligence applications depends on cognitive perception or problem-solving. For example, some techniques using machines overpowered the most prominent professionals in some strategic games such as chess and the famous GO game [11]. Hundreds of companies like Amazon and IBM use cognitive technology to improve business efficiency (optimization) for a huge economic return. Amazon's inventory management system and a system to know the buyer's desires through their website to recommend related products, contributed to the three-fold increase in income. Some retail companies used similar systems to determine the type of advertisements displayed on the site to increase the percentage of purchases and create new investment opportunities from targeted advertising [11].

There are several applications and models for integrated services based on artificial intelligence technologies. Companies like Aptonomy and Sanbot are developing applications using robots and drones to provide security services without the need for security personnel [11]. Other companies are developing techniques for language interpretation and in different languages. One of the noteworthy attempts from the Arab world is Labiba's artificial intelligence platform to design robots for automated response management, which operate through artificial intelligence and fully support the Arabic language. The development of such services and applications requires much research and effort at diverse levels. At present, areas of research [12] include the following:

- Software development, algorithms, and learning methods, which are the main mechanisms that work with big data to extract tacit information through training, learning, or feedback (e.g., natural language processing, pattern recognition, machine learning).
- Tools and development services based on this information that develop a user interface for potential applications (expert system, robotics).

6 Machine Learning

The complexity of artificial intelligence ranges from a general concept based on perception and the ability to analyze various types of inputs and outputs, to the ability to learn from these inputs to change some outputs and methods of analysis, by using implicit systems and techniques such as machine learning. The concept is that machines learn from examples and data rather than being programmed to perform specific tasks. Thus, these machines use integrated knowledge of input awareness and strategies for analysis and learning to find specific solutions. Theories of learning mechanisms can be divided into three categories; see Figure 1.

6.1 Supervised Learning

It is the most successful and widespread learning theory and is a tool for classifying and manipulating data using machine language where previously classified data are used to develop a learning algorithm, and then these data and the developed algorithms are used as a basis for

classifying other, unclassified data [12]. For example: If there is an input of variable X and an output of variable Y , then supervised learning is used to predict the relationship that governs the variables $Y = f(X)$. Thus, the goal is to know the relationship $f(\cdot)$. Thereafter, it can calculate the output for any other input.

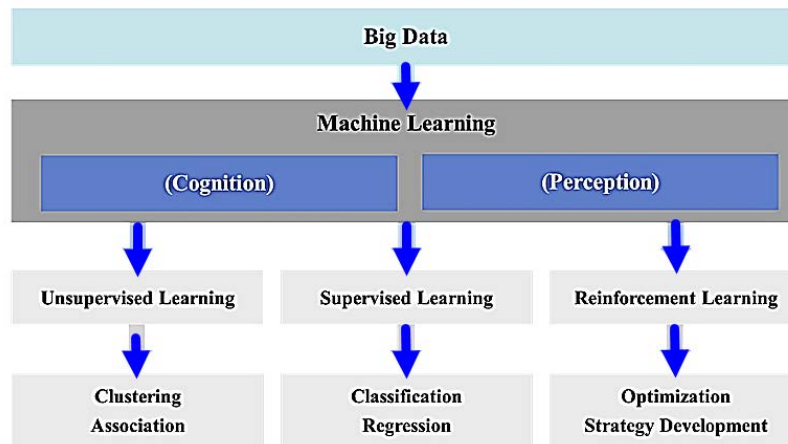


Figure 1: Artificial Intelligence, Machine Learning, and Big Data

When a machine is trained on classified data and linked to specific outputs, it is named a supervision. For example, an algorithm can be developed to determine the names of animals, by first training the machine with pictures of numerous animals and linking them to their names. Therefore, if a new image of an animal appears, the machine classifies it and names it correctly. Supervised learning has many applications such as image tagging, face recognition, and speech recognition.

Furthermore, deep learning theory is a learning theory derived from supervised learning and based on neural networks. Through this, the quality of the output prediction can be improved by using a large quantity of training data. With more training data, more accurate and effective algorithms can be designed for the machine.

Amazon sites use algorithms that have been applied through supervised learning to give users more personalized content [12]. JPMorgan Chase Financial operates on the same theories when implementing its lending review system [11]. Supervised learning is further classified into classification and regression problems.

6.2 Unsupervised Learning

It is one of the most difficult theories to apply as systems based on unsupervised learning learn directly, without prior training. Thus, there is only input of X and no link to a specific, predictable output. The learning aim here is to categorize and relate the available data to each other [13]. For example, through a database, customers' purchasing behavior can be classified, and this information contributes to achieving company or institution goals. This method can be applied to clustering and association problems.

6.3 Reinforcement Learning

Reinforcement learning is learning by interacting with the environment, sequentially, where the machine has a set of decisions or choices to make. The results of the decision are calculated or

predicted based on each decision. Correct decisions are strengthened (reward or positive reinforcement), and wrong decisions are gradually dismissed (punishment or negative reinforcement). Hence, as the experiment repeats, the machine learns which choices and decisions assist to achieve its goals, and what are the wrong decisions. Through reinforcement learning, the programmer defines goals only; not how to reach them. Therefore, goal formulation is especially important for the success of learning and this is done through what is called, utility function. Moreover, the principal mechanism to implement positive and negative reinforcement is called a learning strategy. Learning strategy is based on mathematical models that are distinguished from each other in terms of capacity, effectiveness, and speed [12]. So, some of these strategies may make some systems or machines more intelligent than others. Types of problem-solving: Optimization and developing strategy. Augmented learning theories are suitable for designing and developing artificial intelligence systems in strategic games such as chess and the popular GO game [10]. Microsoft also uses enhanced learning theory to display news in the MSN.com page browser, as it relies on positive and negative reinforcement when users click on news links [11].

7 Inter-library Resource Management and Game Theory

Librarians face many financial and technical challenges. With different priorities and resources, some libraries have focused on developing some resources more than others. This led many of them to conclude cooperation agreements to share some of these assets. For instance, managing some digital resources, catalogs, or collaborating by providing books and references. Shared resource management is subject to many complexities and logistical matters that make it difficult to adopt this strategy considering the high volume of data that could be shared. These processes are more complex when there is a multitude of decision-makers with conflicting goals and interests.

Machine learning theory and game theory may create a common framework for decision-makers. A framework that is based on artificial intelligence can guarantee policies and rights for all participants automatically and seamlessly, facilitate the management of resources, and achieves the goals of libraries. Although game theory has been studied extensively in fields like economics and industry, it has been little explored in libraries and the management of shared resources [13,14,15]. Here we provide a simplified introduction to game theory and its relationship with artificial intelligence.

Game theory is a mathematical theory to analyze processes where more than one decision-maker shares decisions in an interactive environment [16]. Every decision-maker has many options. Each has a different decision-making strategy. Moreover, the decision made by either party may influence the decision of the other party. Like chess, there are two players in the game, each of whom has a set of moves to take each time. The first player devises a strategy to move, chooses stones to win, and builds on decisions in every turn.

Therefore, the most pivotal elements of game theory consist of: The players, the possible decisions, the strategy with which the decisions are made, and the results for each decision. In chess, the options a player chooses are variable depending on the moves of the opponent where the

opponent's decisions make the first player change his tactic to match the opponent by understanding his strategies. This is a process that involves learning. This leads us to a new applied mathematical concept based on machine learning and game theory, which we call learning games. Every decision-maker seeks to learn from the game's experiences and to improve his long-term decision-making strategy [16].

Game theory is represented by mathematical models and varies according to the game environment (work environment). There are many different types of games [16]. Depending on the work environment of a library and the nature of its services, a mathematical model can be created, based on one of the game theory classifications.

Game theory is mature in practice in the industry, technology, and economics, but it is still not applied in libraries. The most prominent challenges lie in decision-makers' understanding of the concept of game theory and its relationship with artificial intelligence; how to represent the relationship between libraries with an intelligent mathematical model; how to choose the terms and laws of the game, which are governed by the type of service or shared resources; how to design the strategy for the decision-maker in the library so that it achieves the library's goals, which may conflict with those of other libraries involved in resource management, see Figure (2).

Considering the multiplicity of decision-makers and interests, the study of theory and researching ways to apply these concepts in academic libraries may create a new horizon in automated decision-making. Redrafting the strategies and information structures of libraries with scientific and engineering methods will make them more amenable to these technologies and assist them to overcome internal reservations and adoption difficulties.

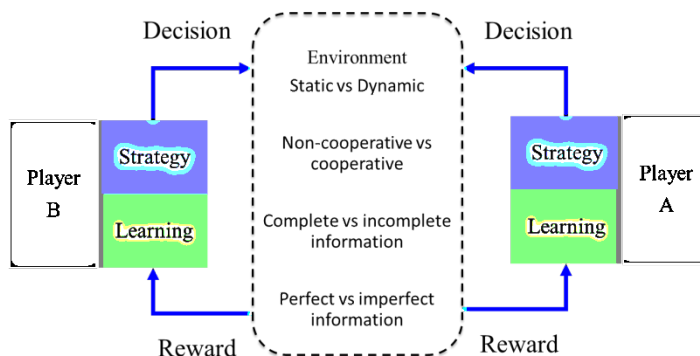


Figure 2: The Concept of Game Theory.

8 Roadmap for Development and Implementation

In the academic libraries context, we look for the implementation agenda for such technologies, as questions focus on how to implement and expand the exploitation of these technologies and their gains. All traditional library services, such as reference services, indexing, classification, and acquisition, can be automated using AI applications. There are many systems and programs available as cloud applications that can be hosted to perform some related tasks. For example, Meta, acquired by Facebook, provides reference services in medical specialties [11].

Nevertheless, how can libraries benefit from the digital infrastructure and maximize the benefits of these technologies? Could libraries be drivers for future industry and developers instead

of being tech consumers? If libraries desire to contribute technologically, they must go through three main stages:

8.1 The First Stage

This stage is the collection and organization of substantial quantities of high-quality data, and require procedures such as cleaning and processing data. The abundance and quality of data aid in developing algorithms designed for rapid learning; thus, the greater the volume of data available for learning, the greater the effectiveness and accuracy of producing useful information and making sound decisions. That is why the expression, "Data is the new oil" is sometimes used. Companies with huge databases are capturing global markets, economically. Companies that acquire a substantial proportion of data can develop their software and algorithms faster and more accurately than other companies can [11]. However, can the data in libraries be useful for artificial intelligence or fit the concept of big data? Can existing data be used to train and learn machine algorithms? The most important question is how to determine the value of these data? Statistics about library services ten years ago may not be of value to the decision-maker, but it is valuable as data for machine language training and learning. Therefore, all digital data in the library, including user records and periodic reports on services, can be used. Note that some of the data used for machine learning lose their value to achieve the same goals after learning and training. However, such data are increasing daily. This emphasizes the importance of adopting a solid base for hosting data, even if we start today. Academic libraries have a large amount of primary and secondary data with relevant content. Creating categories and designing metadata schemas can make data more useful. These contents can be linked and supplemented with data freely available on the Internet and benefit the beneficiaries (an example is the Unified Arab Index). It may then serve as a base for applying machine learning theories. Advances in information and communication technology have facilitated many of the previous dilemmas, such as the size of data, storage spaces, and methods of storing and retrieving data. However, the principal issue is how to obtain clean, relevant, and user-friendly data that allows for useful analysis. Herein lies the need for the skills of specialists in rearranging the data system to develop and operate artificial intelligence applications in the future.

An example of this stage is to design a smart system using artificial intelligence to respond to users' inquiries about library services. This stage requires gathering the largest possible number of inquiries with the answers to them. Each question is linked to the ideal answer (X, Y). All data are classified according to some feature. Then the next stage begins.

8.2 The Second Stage

This stage includes goal setting and development. AI applications are used to define the tasks that the library wishes to complete. For example, smart reference services to answer beneficiaries' inquiries, smart provisioning programs that depend on library holdings, and borrowing operations. Thereafter, algorithms and programs based on machine language and the training of these systems and programs, according to the goal or required task, are developed. We are fully aware of the library's lack of qualified technical personnel capable of designing and developing software based on these technologies. However, companies such as Google, Amazon,

Microsoft, and Salesforce offer numerous applications based on artificial intelligence as a cloud service, for purchase or even to rent [11]. Furthermore, designing such algorithms and programs usually takes a long time of research and experimentation before they become mature for implementation.

Therefore, we do not believe that libraries have a duty to design this software, but to be prepared for "fast followers" by identifying the most important services and procedures in which artificial intelligence techniques can be used.

To extend the previous example of the smart reply system: At this stage, algorithms, and programs rely on sound analysis and signal processing to extract variable input characteristics (voices and questions of different users that are converted into electrical signals, to be processed), are designed. The system is trained by using these variable inputs and the database established in the previous stage. Hence, the system could define any input variable (X) and relate it to the variable (Y).

8.3 The Third Stage

These algorithms are applied in the libraries' business model and performance and impact measurement. During this stage, many challenges arise, such as, how to generalize data and reset algorithms with different data environments and applications; how to adapt the technical infrastructure to the work environment and redesign services in line with technology and its requirements.

To continue with the previous example, at this stage, a user interface is created. Through it, the user can interact with the system, through a program or an electronic application or even robots that listen to the user's question and then convert it into an electrical signal. This signal is sent to the learning algorithms that analyze the data and send the answer to the user interface, to convert it into a language suitable for human perception.

9 The Digital Transformation of King Abdulaziz University's Library

Over the past years, the Deanship of Library Affairs at King Abdulaziz University has focused all its efforts to strengthen the foundations of education and diversify the sources of information, in response to the massive information revolution and upon the desire of the beneficiaries of the faculty and students, to become a scientific edifice and reference supplier distinguished by scientific and huge digital content in all academic and research disciplines.

The deanship's development plan relied heavily on digital transformation, in line with the Kingdom's 2030 vision. Therefore, the deanship resorted to restructuring all its services and electronic infrastructure to become more receptive to developments in information and communication technology. Below are some of these efforts, which we hope can be used in academic libraries elsewhere.

9.1 Library Management System

Most library management systems are relatively conservative, which weakens their competitiveness when it comes to rapid development. Therefore, most efforts in this respect have focused on how to qualify and maximize data. Usually, the data pass from the official records, and

the data of the beneficiaries are captured through different systems and input policies that configure these data and records in various forms and classifications. Therefore, there was a stage for cleaning all records and data and re-entering them according to a unified policy. This included beneficiaries' data, their fields, registrations, diverse types of materials, and the classification of branch libraries. The number of holdings of King Abdulaziz University libraries exceeds one million items. To increase efficiency, some automated programs were used to clean data with high efficiency and accuracy. The sub-entries for the records and beneficiaries' data were expanded in fields that were not previously required. To maximize the benefits from these data, the library management system is integrated with other university systems, such as the e-learning system, the personnel affairs system, the admission and registration system, and other systems containing useful and related data.

Therefore, the libraries have redesigned all servers and modernized them to make them suitable for connections and integrations. All services related to the automatic index have been redesigned and made available through digital applications available on devices that support Android and IOS systems. The goal of all these efforts is to obtain the largest number of disaggregated data and to create a large database to later facilitate automation processes and applications such as artificial intelligence.

9.2 Advance Digital Resources Management System

Most of the efforts in managing digital resources were focused on standardized search engines and on how to make library content such as books, electronic articles, and visual materials available to the public. These efforts undoubtedly contributed to the development of search engines in recent years, especially regarding their support for the Arabic language. Many libraries neglected the importance of data and statistical feedback about the use of digital resources to understand the nature and needs of beneficiaries. Therefore, we designed an advanced interface to revamp the digital library. The user interface is supported by qualitative services such as suggesting the interface to the user or researcher together with the best and most used sources. Furthermore, the innovation can evaluate the sources, thus, making research easier. They are all linked to a management system and an interface to manage the library that displays the data and all statistics about usage, directly. These actions have contributed to increasing the number of beneficiaries of the digital library from about 2,000 to more than 35,000 users in less than 18 months.

9.3 VitalSource

Over two million e-books for e-courses are part of the digital repository. It always suffers from relatively low usage due to its presence in a huge digital repository that prevents students from accessing books, except through research. Therefore, the electronic course books were recently separated into a new database under the name of the VitalSource curriculum books' platform linked to the university's e-learning system. As the platform is linked to virtual classes through Blackboard, all students can get their textbooks from the first day of school without going back or searching the library. Additionally, the platform offers many interactive tools and supportive educational materials to ensure an excellent educational experience, integrated with the

Blackboard e-learning system. This experience contributed greatly to the smooth access of textbooks by students and faculty, and an increase in the level of satisfaction among users, especially in the absence of distance learning policies.

9.4 Investing in Services and Knowledge

The deanship's transformation plan aimed at investing in services, by restructuring services and designing new, high-quality, data-driven services. These investments have contributed, directly or indirectly, to improving the level of services and increasing the use of the content and holdings of the library. One of these successful projects by the Deanship of Library Affairs of King Abdulaziz University is the creation of the Audioketab platform and application for book summaries and audio lectures. It is an interactive electronic platform available in the form of a website and an application on mobile devices, both on Android and IOS operating systems.

The platform is based on the concept of open-source provisioning, whereby all users can provide the platform with their productions of book summaries and audio lectures and upload them directly to the platform, and has recently expanded to include podcast activities, which directly contributed to the significant growth of audio content during the last period. It is impactful in serving visually impaired students' special needs.

Moreover, it helped to attract users to the library to use private studios to record seminars or their audio programs. The deanship participates in many local and international exhibitions with the application. The platform also formed a good database of users, their desires and voice skills. The number of users of the application reached about 10,000, from all over the Arab world. Through the data, most follow-up participants were identified, and several projects were implemented to produce audio books and agreements and partnerships were signed with the private sector. This is a good example of the importance of creating a useful database and monetizing it.

Another example of investing in redesigning services is through interactive libraries. It is a new concept in libraries and involves presenting scientific and knowledge content in interactive forms and in assorted styles. The Materials Library at King Abdulaziz University is one such example of an interactive library. It is a library that contains more than 1500 paintings that are samples of materials used in industry. It uses a set of applications, databases, and interactive tables that operate with multi-touch technology, and contributes to accessing the materials database to understand and study the components of these materials and their usability and improvement. The database contains more than 10,000 articles. Information on these materials has been organized and classified to facilitate links to applications and industrial companies.

9.5 Digitization of Thesis, Dissertations, and Manuscripts

Many efforts have been made to digitize theses and dissertations and convert them into digital copies, available through digital repositories that can be accessed at any time and anywhere. They are available with all technologies that enable the researcher to search in titles and within the content of a thesis. The manuscripts represent the history of the nation, as well as a major

document that is a pillar of knowledge and cultural balance. They store knowledge, thought, science and art. They dehambrate their importance in preserving identity and history as they combine tangible and intangible heritage in form and content.

The importance of the manuscript remains, even with the presence of the printed book therefrom, because the value of the manuscript does not come only from the words it contains, but its supreme merit comes from it being a work of art from the era of mechanical production, its temporal and spatial existence, the types of calligraphy, its decoration, its relationship to the era, and its history. This makes the manuscript an open window on the art of calligraphy and the science of drawing the letter and its significance. Due to the scarcity of some of these manuscripts, the damage in some of the papers, or the lack of clarity about the calligraphy, there was great difficulty in them being accessible as a treasure of knowledge and benefiting users with their science and knowledge.



Figure 3: A project on digitization of manuscripts, while in the right part appears a high-quality processed image of the Arabic language manuscript, and the left part of the same page after digitization thereof.

All these justifications were good reasons to start converting the manuscripts in the Deanship of Library Affairs at King Abdulaziz University into a digital image that was uploaded to a special platform under the name (KAUPP). Through this initiative, our goal is to serve the cultural and scientific heritage by preserving and displaying the manuscript in a digital fashion that corresponds to the times and makes it easy for researchers to access and benefit thence.

The modern digital image of the manuscript enables all researchers to read the manuscript with ease and convenience, as well as search within the manuscript content through a database and digital platform, see Figure 3. This value lies not only in the availability of manuscripts but also in the availability of valuable information within these manuscripts that can now be easily searched and used. It, therefore, creates a huge database of clear pictures and explanations.

10 Conclusion

There is no doubt that the development of e-learning and the use of applications based on artificial intelligence have created many challenges as well as opportunities for library workers.

Considering the lack of technical personnel who understand these technologies, it was necessary to shed light on them and explain concepts and various mechanisms.

Through this paper, the techniques and their adaptation to the academic library environment were studied from three distinct aspects. The first aspect focuses on the importance of data and how to maximize the benefit of big data. It summarized the necessity to re-structure, organize and classify data to become comprehensive enough to include all library holdings and content, user data, and their practices. We examined the necessity of storing periodic reports of procedures and statistics in the database. The large volume of the data expands the potential usefulness of the data for AI application development.

The second aspect emphasizes services, including the traditional services of the library, technical procedures, indexing, classification, and services for the beneficiaries. A set of suggested examples and similar experiences from other sectors that may inspire library workers are highlighted. We mentioned therein the necessity to re-design the services with a focus on the user environment and not on the content (user-centric services). All potential ideas and applications based on emerging technologies are applicable to libraries. This is either through development by librarians, expansion by specialists in technology and information technology, or by using the products of specialized development companies that have spent a lot of time and money preparing a reliable, tested, and highly effective product. It is much faster and saves the time of library workers. However, most important, is to place it in the context of integrated services linked to the huge database based on cognitive intelligence.

The last aspect is a data-driven presentation of the future of management and decision-making as financial and technical challenges, and varied infrastructure and efforts are forcing many libraries to cooperate to face these difficulties. With learning and game theory, there may be a common framework for decision-makers, based on artificial intelligence that guarantees policy implementation and rights for all participants. Although game theory has been studied extensively in fields such as economics and industry, it has not been studied in an applicable way in libraries and the management of shared resources. This paper presents a comprehensive concept of emerging technologies and that libraries have the means to enhance their position in the education system in support of scientific and research mobility, especially in the era of free learning and e-learning.

11 Availability of Data and Material

Data can be made available by contacting the corresponding authors.

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