An Appraisal Towards the Technological Improvement of Library Operations Management in Digital Era

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Abstract: Operations management has turned into a challenging agenda for non-profitable organizations in the current competitive world. To better resolve such issue, technological and digital advancements pave the way to improve the efficiency of activities, and in this context, library serves significant potentials. This transformation within library, primarily demands for identification of activities contributing to the accomplishment of operations management, which is addressed in this paper through literature study in combination with field observations and discussion with librarians. This phase is followed by investigation of feasible digital technologies that potentially contribute to the upbuilding of the outlined activities. Given the current high-pace digital era, the findings of this study demonstrate that activities in library serve significant potential for digital promotion. For instance, material handling could take the advantage of autonomous mobile robots (AMRs) and artificial intelligence (AI). However, there are some limitations that are deemed essential to be considered prior to such transformation, and these barriers are articulated in this study.

Keywords: Library, Digital Technologies, Operations Management, Library Activities

1. INTRODUCTION

The word 'library' commonly evokes an image of a quiet and peaceful environment decorated and filled with reading materials and scientific assets. Nowadays, however, this definition is extended to a service-oriented entity that not only facilitates public access to scientific documents, e.g., books, journals, etc., but also aims to support corresponding educational and research activities, such as group meeting, language café, and so forth (Tiwari, 2016). Beyond such materialistic goals, the core mission of library is improvement of knowledge, skills, and education within a society, and more importantly, to create a cultural and scientific value for the local community (Cao et al., 2018). This highlights the fact that development of societies has modified the inherent of library rather than just a stock keeping facility, but to provide various services. This turns library into an organization where the operations management becomes even more complex to comply with such extended goals, as a non-profitable entity.

Operations management in organizations, be it public/private or profitable/non-profitable, refers to the administration and organizing the resources that contribute to creating and delivering the demanded products or services to the clients (Slack et al., 2013). This triggers the *operations function* which is the core of an organization and corresponds to the transformation of inputs to the desired outputs. Needless to mention, that marketing and finance are two other functions in the enterprises that support operations function (Stevenson, 2018). Although the operations function, commonly denoted

as 'operations', vary depending on the type of provided goods or services, there are some generic and prominent *activities* that are to be accomplished within this framework: demand forecasting, capacity planning, layout planning, inventory management, just to name a few (Stevenson, 2018).

Whereas library is no exception in this context, outlined activities are scalable and integrable into the library operations management. From a holistic standpoint, these activities are comparable, but not limited, to demand forecasting of individual objects/services; planning the required resources for service provision; decisions regarding layout of bookshelves, racks, and studying area within library; movement of objects within the library environment; inventory of objects and information; delivery of orders. Equivalently, aiming at higher satisfaction level for *patrons* (better term compared to customer in this context since the service is majorly free of charge), operations management in library seeks to improve the efficiency and effectiveness which is particularly challenging within a non-profitable organization. The outlined activities, on one hand, are widely performed through manual processes which require notable human efforts and costs; while on the other hand, there is a significant potential to eliminate such deficiencies thanks to the latest technological and digital solutions. For instance, Radio Frequency Identification (RFID) has shown promising utility in reducing the time required for circulation and shelving the documents, objects tracking, book borrowing, and inventory control in the library (Singh and Mahajan, 2014, Shahid, 2005). The list of digital technologies is not limited, and organizations can take the advantage of various solutions, which have been less observed in the library, such

as Machine Learning (ML) and Deep Learning (DL) in connection with demand forecasting (Jafari et al., 2022), Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) as advantageous means contributing to material handling and inventory management (Maheswari et al., 2018, Berman and Edan, 2002, Fragapane et al., 2021).

While remarkable research works have been carried out to highlight the significance of digital technologies for improvement of operations management, only few efforts have been directed in the context of library. To address this gap, this paper puts forward to identify the primary activities involved in the library operations management, which is followed by an investigation of feasible digital solutions that potentially contribute to the enhancement of those activities. To that aim, we primarily employ the operation management concept in the library environment to identify the major activities within this service-oriented organization. However, due to the scarcity of literature in this context, the Trondheim Public Library of Norway is considered as the basis of comparison to conduct a thorough investigation and enrich the findings with the observations and discussion with librarians and academicians. Furthermore, we study the major digital technologies that have favoured organizations and industries in the accomplishment of such similar activities. This research effort contributes to assessing the functionality, advantages, and limitations of beneficial digital technologies, and shaping the ground to direct the library activities towards digitalization. It is noteworthy to mention, that the identified activities are structured at a high abstraction level for the sake of generalization and applicability, and thus, there is a possibility of variation if one aims at articulating the operations pertaining to the library of interest. In addition, the incorporation of technologies would trigger several physical and operational constraints and might vary in different environments, which will be discussed in this study.

The remainder of this paper is structured as follows. The primary activities of library are studied and highlighted in section 2. Section 3 investigates the feasible digital technologies to improve the identified activities. Section 4 discusses the contextual benefits and limitations of the appraised solutions. Section 5 concludes the paper.

2. OPERATIONS MANAGEMENT IN LIBRARY

Library serves the local community as a non-profitable entity that beyond the general goals, seeks to play a key role in knowledge development. This imposes specific challenges to the operations management of such system, particularly in comparison to profitable organizations. Long-time or life-time inventory of valuable books and objects, order fulfilment of different patrons demanding one unique item in the absence of existing any copies of such, managing the intensive return rate of books and other materials, are only few instances of challenges involved in the library operations management.

The main input of the library operations which triggers every individual activity in this system, is patrons' demands. Patrons are supposed to attend the library with different demands in expectation of receiving corresponding individual

services, which is equivalent to a transformation process. The primary output of the library, vis-à-vis, is a service-received patron. Not to mention, that personnel, books, facilities, and equipment are also amongst the inputs of library, according to their role [as the resource] in the transformation processes (Slack et al., 2013). Hence, it is vital to identify and articulate the major activities that contribute to patrons' experience, and thus, facilitate the improvement of them which leads to higher effectiveness and efficiency of operations management in library. In this regard, six generic activities are identified and explained in the remainder of this section.

1. Demand Forecasting. It is one of the preliminary activities in any organization to assist in assuring the availability of corresponding resources and planning the relative activities. In the library operations management, this activity is bilateral, given the essence of predicting the future demands of not only the individual goods, i.e., books, journals, etc., but also the major services provided by the library, e.g., organizing the events, preparing educational and research meetings, etc. This is particularly important and challenging according to its connection with other activities, and most importantly, due to the limited number of resources, either staff or objects. It is worthwhile to mention, that projecting and analysing the demand patterns is as equally important as numerical forecasting, as it can potentially lead to better performing of other activities in the library, such as capacity planning, layout planning, and inventory management.

2. Capacity Planning. This activity is associated with specifying the required resources for delivery of the desired outputs, which is challenging in organizations, due to the ever-existed constraint of available resources (Arnold and Chapman, 2004). Primarily, and unlike many other types of organizations, there is a critical shortage of the available items in the library. For instance, the number of available copies of a highly demanded book is not comparable to the number of received or forecasted requests, and the library is urged to apply corresponding strategies for satisfying the patrons, e.g., shorter borrowing periods in comparison to other types of documents, supplying the shortage of such book by borrowing from other libraries (equivalent to sub-contracting), etc. It is noteworthy to mention, that the return of borrowed items is an inseparable part of capacity planning. Capacity planning in library also attempts to determine the required resources not only for satisfying the patrons demand, but more importantly, to facilitate an efficient provision of the required services. This challenge is resonated at special occasions throughout the year and capacity must be strictly adjusted to avoid the risk of low service level. For example, there are significant inquires of meetings, public events, and so forth, during the Christmas which require higher utilization of resources of the library. Another implication of this issue is exam periods according to the school calendar which implies higher borrowing rate of books as well as higher requests to reserve either meeting or studying rooms.

3. Layout Planning. Layout planning or facility layout planning (FLP) is one of the most influential components in conjunction with overall performance of a system, and it refers to the arrangement of equipment following the goal of

higher efficiency (García-Hernández et al., 2013). This activity in the context of library deals with the arrangement of bookshelves and racks, studying areas, service check points, and so forth, where the prominent objective is higher efficiency in providing service to the patrons. From the patron's perspective, this is translated to lower time spent in the library for the desired service, e.g., borrowing book, returning the items, finding a document, etc., or a peaceful experience in the library environment. Thus, the layout of individual physical objects throughout the whole areas of the library must be designed to meet the patrons' expectations. On the other hand, this implies continuous arrangement of facilities to adapt with the required modifications to maintain the service level. This is specifically realized in the event of social and research gatherings which require facility rearrangement not only to deliver the corresponding services, but also to satisfy other requests as well. It is worthwhile to note, that layout planning seeks to minimize the efforts required to fulfil the patron's demand. In fact, the goal is not only to optimize the staff utilization, but more importantly to minimize the required working hours for performing a task. In this regard, drop-off or pick-up check points are considered beneficial to library layout planning given their automation feature which leads to less required human effort.

*4. **Material Handling and Warehouse Management.*** In general, this activity encompasses the movement and storage, of objects, i.e., materials, semi- and finished products. In library, it majorly refers to the movement and storage of documents, i.e., books, journals, articles, etc., which shapes the underlying difference between this system and other organizations due to the remarkably higher variations of goods inside the library. In fact, material handling in library embraces thousands of *unique* objects, as opposed to other sorts of organizations or production systems; even compared to a flexible manufacturing system that serves clients with high variety of products. This issue becomes more challenging for sorting processes which include either requested or returned documents as it demands high accuracy and efficiency to avoid wrong delivery to patrons or wrong placement of objects in the shelves. Moreover, storage of scarce or valuable books is of particular importance in the library given the intention of preserving such documents to comply with the knowledge development goal. While library is a non-profitable entity, this effort compromises the cost efficiency for library operations management.

*5. **Inventory Management.*** Inventory management comprises several major activities, such as, planning, developing, controlling, and so forth, at various stages throughout an organization; for instance within a production system, ranging from raw material retrieval to final delivery of goods (Arnold and Chapman, 2004, Oluwaseyi et al., 2017). In library, the physical objects, e.g., books, journals, etc, serve as raw material which are to be processed according to the patrons' requests. Preparation of the received orders form an accumulated queue and intermediary inventory, which is equivalently identified as work-in-process (WIP). Ultimately, the processed orders are stacked up and organized in a particular place, for them to be picked up by the corresponding patrons. In this regard, attention to the

returned items is deemed necessary. In fact, returned items must be processed for positioning within their corresponding spot for inventory or being delivered to another patron to serve the waiting orders; either case, they form an input to the system and trigger raw material inventory tasks. Last but not least, is the inventory of information given the existence of numerous items in library. In this regard, it is strictly important to track and control various information associated with every single item, particularly books, to respond various demands without compromising the service level. This implies developing and maintaining databases which keep the track of different data associated with books, e.g., stock keeping identification (ID), inventory position, category, etc.

*6. **Transportation and Distribution Planning.*** In library this activity refers to the processes and strategies of transporting or distributing items among patrons/other libraries (or branches of the same library). It contributes not only to the cost efficiency, but also to the service level. Assuming that a patron intends to borrow a book from a library while this item is kept in another branch and must be transported to the corresponding branch where the order has been placed. To fulfil this order, several tasks and compromises are integrated with the transportation activity. The challenge primarily arises with maintaining the service level in case the patron's order is to be responded within a tight agreed time frame. In this regard, there is a considerable trade-off between the service level and cost efficiency; higher service level requires quick response to the demands and orders, while such aim could potentially put cost efficiency at risk, where the library can lose the chance of benefiting form economy of scale. In fact, various decisions must be made within the framework of transportation and distribution planning to optimize the operations management at library. In this context, and in the existence of other branches, the major question is the inventory place of objects such that the transportation expenses and service level are at efficient frontier. This challenge also triggers the issue of decentralized and centralized warehousing which not only affects the cost efficiency, given specially the non-profitability feature of library, but also has a direct impact on the distribution efficiency. In general, specifying the optimal capacity and policy of transportation and determining the transportation means in connection with the cost efficiency issues, are just few of decisions in this context, where the decision-making process is entirely influenced by the desired service level.

3. DIGITAL TECHNOLOGIES IN OPERATIONS MANAGEMENT

Technological development has significantly influenced operations management, in terms of efficiency and effectiveness, and these improvements have been expedited, and contributed to better delivery of goods/services to the clients, e.g., advancement of industrial robots, development of the internet, artificial intelligence (AI), etc. In fact, technology has provided considerable opportunities for organizations to enhance their capacities and better meet the clients' expectations, as well as preserving their competitive advantage. In this regard, RFID is one of the prominent technological alternatives that has largely benefited the

library operations management. The ability to find, track, register new records, and so forth, are only few of features that RFID could benefit the activities in the library, such as inventory management (He et al., 2020). According to the continuous development of the pool of digital technologies, library as a non-profitable organization, serves significant potential to integrate with the new solutions to meet its efficiency goals. Hence, this section puts forward to shed light on some of the feasible and promising technologies that have been developed and practiced in the organizations and could potentially be incorporated into the library.

1. Internet of Things and Cloud Computing. Internet of Things (IoT) enables various sorts of connection in a system: human-to-human, human-to-things, and things-to-things (Aggarwal and Das, 2012). Such platform provides the possibility of higher communication level and data processing capability which leads to better operations management. In addition, internet connectivity enables the incorporation of other technologies, e.g., cloud computing, RFID, AI, etc., which notably boosts the system integration and ultimately results in higher efficiency. For instance, transportation and distribution planning has benefited from IoT to track the vehicles' locations, movement monitoring, position prediction, and so forth (Barreto et al., 2017). This approach has also benefited inventory and warehouse management in conjunction with enumeration, monitoring, surveillance (status, and position of objects), prediction and forecasting, and so forth (Lee et al., 2018). Not to mention, that RFID in this context has an equal practice and importance as IoT to establish such platform. In this regard, the IoT-enabled systems could also benefit from the integration of sensors and detection devices to improve the workflow and productivity, which is realized in the realm of material handling (Azizi et al., 2018).

2. Artificial Intelligence. Artificial intelligence (AI), above automation and integration, facilitates the realization of self-cognition and self-configuration, contributing to decision-making optimization and higher resilience at system administration level (Lee et al., 2015). This implies that operations and activities can be embedded with AI tools, e.g., ML, DL, to benefit from the capacities of this technology at its utmost. High data processing and calculation capacities, in this regard, improves demand forecasting as well as inventory management that particularly impacts the service level and efficiency (Praveen et al., 2020). Projecting and analysing the patterns of inventory changes, estimation of future required capacities, are just few implications of AI. Given estimation and forecasting features, transportation can excel at addressing various sorts of problems, e.g., vehicle routing, scheduling, problems freight consolidation, etc (Min, 2010). These benefits can be extended to the processes and devices corresponding to material handling and warehouse management not only to improve the operation time, safety, resilience, but more importantly to incorporate self-learning (Er et al., 2021, Al Mammun et al., 2021).

3. Radio Frequency Identification. RFID is one of the technologies that has extensively benefited operations management in library, by providing wireless information

exchange. One of the advantages of this technology is enabling the traceability and visibility of items, facilitated by RFID tags, in order to combat misplacement and positioning deficiencies in inventory management (He et al., 2020). Information distributed through RFID channels contributes to real-time data exchange which is extremely important for efficiency of activities in the library, such as material handling, transportation, and warehouse management. Exact positioning, tracking the movement, and calculating the moving/arrival time of items are amongst the benefits of RFID in this context. This enhanced platform enables better decision-making regarding various aspects, such as better organizing of movement inquires, selecting the suitable equipment for handling, and so forth (Barreto et al., 2017, Lee et al., 2018). Needless to note, that as outlined earlier, such connectivity and integration is realized in the presence of IoT. The combination of RFID and IoT along with data synchronization facilitate the incorporation of more novel and technological solutions associated with various operations and activities; automated storage and retrieval system (ASRS) have shown particular benefits in automating the warehouse management; unmanned aerial vehicle (UAV) assists in minimization of transportation efforts and expenses (Baniasadi et al., 2020).

4. Autonomous Robot. Autonomous mobile robot (AMR) has shown specific benefits in the domain of material handling not only due to its applicability in limited areas, but also based on several intelligent features, such as object detection which leads to a collision-free ride. Decentralization has enabled AMRs to communicate with other objects individually, e.g., AMRs, human, machines, and perform decision-making accordingly (Fragapane et al., 2021). This feature facilitates the integration between automated guided vehicles (AGVs) and industrial robots to exercise intelligent routing and better decision-making process in this context (Wang, 2016). In one study, the combination of puzzle-based storage and retrieval system with AGV tractors has shown positive performances associated with access time and storage efficiency, as well as minimizing the size of aisles used to access the materials in the warehouse (Alfieri et al., 2012). UAV, as another means of autonomous transportation, has extensive practices in inventory management by providing the possibility of counting and localization through a collision- and -obstacle free travel (Khan et al., 2022).

5. Virtual Technologies. Simulation is amongst the technologies that has consistently favoured organizations and manufacturing sectors during the last decades by imitating the systems' behaviours under the existence of various dynamics and scenarios. The development of hardware and software has not only extended simulation capabilities, but also led to the development of new solutions such as virtual reality (VR) and augmented realty (AR), collectively known as virtual technologies (VTs) (Azarian et al., 2020). The capabilities of simulation in the digitalization era are not limited to the high computation capacity, but more importantly, the added virtual features have turned it to an exquisite approach with versatile applications; simulation with embedded optimization tools and visualization features

leads to better decision-making process in transportation and distribution management from the viewpoint of cost and time efficiency (Jafari, 2022); virtual factory (VF) assists in developing a manufacturing plant by performing simulation in a profound virtual environment including several elements of a factory with scalability properties (Sacco et al., 2010). This approach not only assists in capacity planning and bottleneck detection, but also provides opportunities for better layout planning given visual capacities. Needless to mention, that decisions regarding material handling and inventory management become more transparent and comprehensive due to higher level of details in such environment. The possibility of integration between simulation and VR has pushed the boundaries in this regard and one may investigate shortcomings and deficiencies of activities and processes involved in the operations in an interactive manner. It is worthwhile to mention, that such approach provides a cost-efficient platform for organizations, to assess various decisions in offline mode for further implementation (Azarian et al., 2020). This is certainly advantageous for non-profitable organizations not only to optimize the operations, but more importantly, for training and educational purposes (Jafari et al., 2022). For instance, new employees could experience the working environment and interacting with other processes and machines in a virtual environment without compromising any safety measures. In this context, AR serves significant potentials to assist workers with their tasks, by giving them useful information and instructions to optimize the workflow and accuracy, such as smart AR glasses (Romero and Stahre, 2021).

4. POTENTIALS AND LIMITATIONS IN LIBRARY

The digital transformation and technological development have benefited various organizations in the last couple of decades to tackle their challenges with respect to efficiency and service level. The application of autonomous robots in Amazon Co. warehouses, internet-based processes in post offices and many service-oriented organizations, RFID in the library activities, are only few examples in this context. In this regard, the technologies discussed in the previous section shapes the ground to accommodate the library activities with digital solutions to a larger extent. Given RFID as one of the established technologies in the library, there is a particular capacity to promote the inventory and material handling activities with IoT and cloud computing. This approach leads to real-time information exchange, through which not only staff can have control over the items and available capacity, but also patrons could take the advantage of automated borrowing platform. In this connected environment, the incorporation of AMRs, in the existence of sorting machines, builds up a machine-machine communication which has a major contribution in moving towards a lean material handling system between working stations and inventory racks. It is noteworthy to highlight, that AI has extensive utilities in this regard to extend this approach towards human-machine interaction in an efficient manner. AI tools has also shown particular utilities in prediction models, and this is beneficial to integrate with demand forecasting. It is also of significant to empower the human efforts with AR where either patrons or staff can get extra instructions adapted to

their needs, such as using AR glasses to find the required document or place.

There are, however, some limitations in such digital transformation. People in the library are majorly not aware of their surroundings due to high level of concentration and this requires extra attention pertaining to the incorporation of robotic solutions where the safety measures are strictly high. Not to mention, that technologies must comply with some critical criteria in the library environment, such as silence. Another restriction refers to the structural design of libraries. In fact, the building and physical structure of the library impose challenges to utilize some technologies that requires specific space for technical and safety reasons. For instance, ASRS requires a minimum hight which might be hardly met in the main corridors or hallways of a library. This also limits the utilization of UAVs/drones that not only requires space for utility purposes, but also for compliance with the safety requirements in an indoor environment.

5. CONCLUSION

Libraries in societies above intermediary objectives, seek to play a key role in knowledge development. While this has consistency with providing valuable items and services, it requires efficient operations management from organizational perspective, given library as a non-profitable entity. In this regard, technological development and digital transformation of organizations provide positive potentials to tackle the deficiencies in library activities. This study investigated various digital solutions that could be of significance to integrate with these activities; RFID and IoT leads to generating a connected network with real-time information exchange possibilities to better perform the inventory and material handling tasks; AMRs with AI features could notably improve the transportation and material handling procedures, where AI could solely contribute into better demand forecasting; AR-embedded equipment for more efficient workflow.

The room for digital improvements is, however, limited by some factors including, but not limited to, safety measures which must be strictly complied in the library, or structural and physical limitations associated with some technologies, e.g., drone. This paves the way to highlight a future research agenda, in which carrying on research regarding technical aspects of incorporating the outlined technologies in the library has a high value. To best serve the manifest of higher efficiency within the library according to the digital technologies, it is also of benefit to evaluate the possibilities of combining the discussed technologies corresponding with linking the activities. This research agenda requires an investigation of optimal arrangement of technologies, as well as the associated technical barriers. In addition, the realm of 'digital transformation' has extra-technical dependencies, rather than only technical aspects. In particular, cultural barriers in an organization would challenge the upgrading of activities, and this has been investigated by researchers and practitioners in different types of organizations. It is also essential to detect these barriers in the environment of library

and facilitate a smooth path for digital promotion of library activities from administerial standpoint.

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