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Technological Advancement and Machine Tool Obsolescence: A Case Study of University of Maiduguri and Ramat Polytechnic, Maiduguri

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Abstract: *Machine tool development undergoes continuous evolution driven by shifts in demand, material availability, and technological advancements. The rapid pace of technological change poses challenges and opportunities, particularly in the context of fast-moving technology, leading to product obsolescence. This study investigates the challenges and prospects of machine tool obsolescence in the University of Maiduguri and Ramat Polytechnic Maiduguri, crucial centres for learning and innovation in engineering in Maiduguri. Focusing on the impact of technological advancements, the research reveals a mix of functional and non-functional machines in both workshops, with a higher rate of non-functionality observed in machines purchased in 1979 and 1985. Key factors contributing to machine tool obsolescence include age, lack of obsolescence management, budget constraints, absence of machine component stock, and minimal maintenance efforts. The study proposes a comprehensive strategy for updating and upgrading the machine tool inventory, emphasizing the need for proactive measures to address technological advancements and ensure sustained efficiency in educational workshops.*

Keywords: *obsolescence, age, constraint, stock and effort.*

1. INTRODUCTION

In the normal course of machine tool development, it often becomes necessary to change the design of tools and systems consistent with shifts in demand and with changes in the availability of materials and components. When the majority of constituent parts of a system are technological in nature, the short product life cycle associated with fast moving technology changes is both a problem and an opportunity for manufacturers and end-users (Rai & Terpenny, 2008; Roy, et al., 2016).

When a machine tool evolves, it is subject to changes in its functionality, technology, and form. While adding functionality and value, the fast-moving technologies also make products obsolete quickly (Amankwah-Amoah, 2017). This leads to obsolescence of the old model. Obsolescence occurs when products become “out of use” or “out of date” (Du, et al., 2017)In terms of product design, obsolescence is a measure of a product’s loss in value resulting from a reduction in the utility of the product relative to consumer expectations (Mellal, 2020). It should be noted that while the absolute usefulness of a tool may remain constant, if consumer expectations increase, the product may realize a corresponding reduction in value. Such a loss in value is said to be the result of obsolescence (Trabelsi, et al., 2021). The relative loss in product value could be due to various reasons such as styling changes or quality improvements in subsequent versions of the product. Obsolescence is a state in product’s lifecycle which occurs when a product is no longer “wanted,” even though it may be in good working condition, and fulfilling its intended function for which it was designed (Li, et al., 2019).

Obsolescence may occur in different ways. In the literature several types are identified, among which we can cite those illustrated in Figure 1.

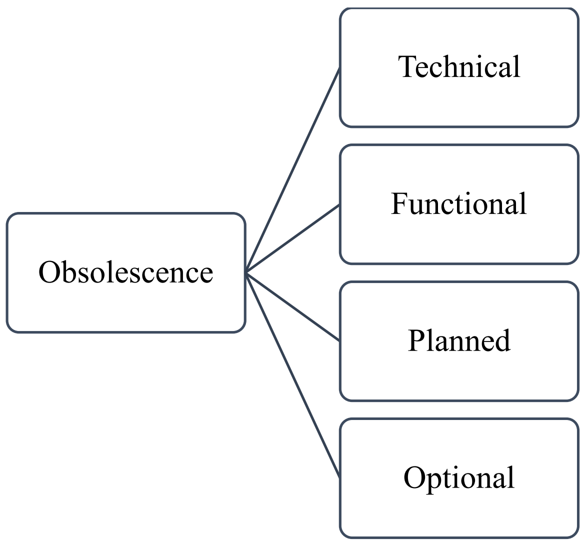

Figure 1: Topology of obsolescence (Mellal, 2020)

One of the primary reasons for machine tool obsolescence is technological obsolescence (Amankwah-Amoah, 2016). Technological obsolescence results when end-users are attracted to functions in newer models of products as the result of advances in technology, rendering older versions of the product obsolete (Mellal, 2020). Technological obsolescence does not necessarily impose functional obsolescence (Trabelsi, et al., 2021). Technological obsolescence occurs when a new technology can replace an older one. Functional obsolescence concerns the reduction of the usefulness, reliability, or performance of a system due to a change in its function (Mellal, et al., 2017). However, most of the time, technological advancement comes with new functionalities.

The University of Maiduguri and Ramat Polytechnic Maiduguri, being centres of learning and innovation, have traditionally relied on machine tools to train students and carry out research activities. These machine tools range from lathes, milling machines, and drilling machines to advanced computer numerical control (CNC) machines. However, as technology advances, older machines become outdated, leading to challenges in keeping up with the latest industry standards and practices.

Technological advancement has revolutionized various industries, including education (Bosch, 2018). In educational institutions, keeping pace with technological advancements is crucial to provide students with up-to-date knowledge and skills. However, one significant challenge faced by educational institutions, such as the University of Maiduguri and Ramat Polytechnic Maiduguri, is the issue of machine tools obsolescence. Machine tools are essential for practical training in engineering and technical disciplines. They enable students to gain hands-on experience and develop the necessary skills for their future careers. However, rapid technological advancements often render existing machine tools obsolete, as newer and more advanced equipment becomes available. The problem arises when educational institutions struggle to maintain and update their machine tools to keep up with technological advancements. Limited financial resources, inadequate infrastructure, and lack of awareness or priority given to technological upgradation are factors that contribute to machine tools obsolescence in educational institutions. The aim of this study is to assess the challenges and prospects of machine tool obsolescence in the University of Maiduguri and Ramat Polytechnic Maiduguri as a result of technological advancement

2. BRIEF LITERATURE REVIEW

The function of a manufacturing equipment or system is related to its ability to perform the tasks for which the equipment was produced (Sénéchal, 2017). In this context, Panneerselvam (2012) explains the gradual loss of this ability or, in other words, the process of equipment deterioration in two main aspects. The first is related to the incapacity of the components of the equipment to perform their functions, while the second relates to technological obsolescence. Incapacity is caused by physical changes through use, fatigue, wear etc., resulting in increased maintenance costs. The second may have a direct impact on the product and/or operators involved, due to the use of technologically obsolete equipment. With regard to the operators, in addition to excessive manual work compared with more modern equipment, the equipment may not meet new safety recommendations, which have been modified over time. Concerning the product, technologically obsolete equipment can influence directly the quality of what is produced (Guo, 2017).

Equipment obsolescence has been studied by many authors. Lawrence and Tanchoco (1990) carried out a study to assess economic obsolescence for a multi-equipment environment, based on investment, production, and marketing information. Hartman and Murphy (2006) explore if the economic life analysis for infinite-horizon equipment (including purchase, operating and maintenance costs), is a good policy for the finite-horizon problem, which occurs when companies only require an asset for a specified length of time, usually to fulfil a specific contract. Tan and Hartman (2010) expand equipment replacement analysis for the case where the horizon is not infinite or finite, but will last at least T_s periods but may last as long as T_l periods, due to uncertainty in the length of production runs or the temporary provision of services. Oliveira and Duque (2011) used partial differential equations to indicate the moment for equipment replacement. Pingle (2015) proposed a model to evaluate obsolescence in a multicriteria decision environment, based on quantitative and subjective factors.

A common concern among these works is the special attention given to the economic dimension and eventually the environmental dimension is included for the assessment of obsolescence. The study by Sénéchal (2017) deals with the application of concepts related to the triple bottom line in assessing the depreciation of a piece of equipment. The author proposed a procedure to verify the sustainability condition of a machine as a function of monitored indicators, to assist in choosing the correct maintenance policy. The decision for replacing the equipment is made by comparing obsolete equipment with possible replacement alternatives (Ravi, 2015). According to Ravi (2015), when the relevant factors used in the comparison are converted to a financial basis, the best alternative can be chosen by applying economic evaluation methods. Among the existing methods, in this work the payback period assessment was used, which represents the time of economic return on investment resulting from the gain from equipment exchange. However, by not taking into account the cost of money over time, the more traditional evaluation method known as simple payback was replaced by the discounted payback period (Jan, 2017). Because this study encompasses several machine tools, the obsolescence indicators considered in this study are age, functionality and presence of advanced substitutes.

3. METHODOLOGY

The methodology for this research involves a quantitative approach using a questionnaire survey as the primary data collection method. The research framework, as depicted in Figure 2, guides the overall process.

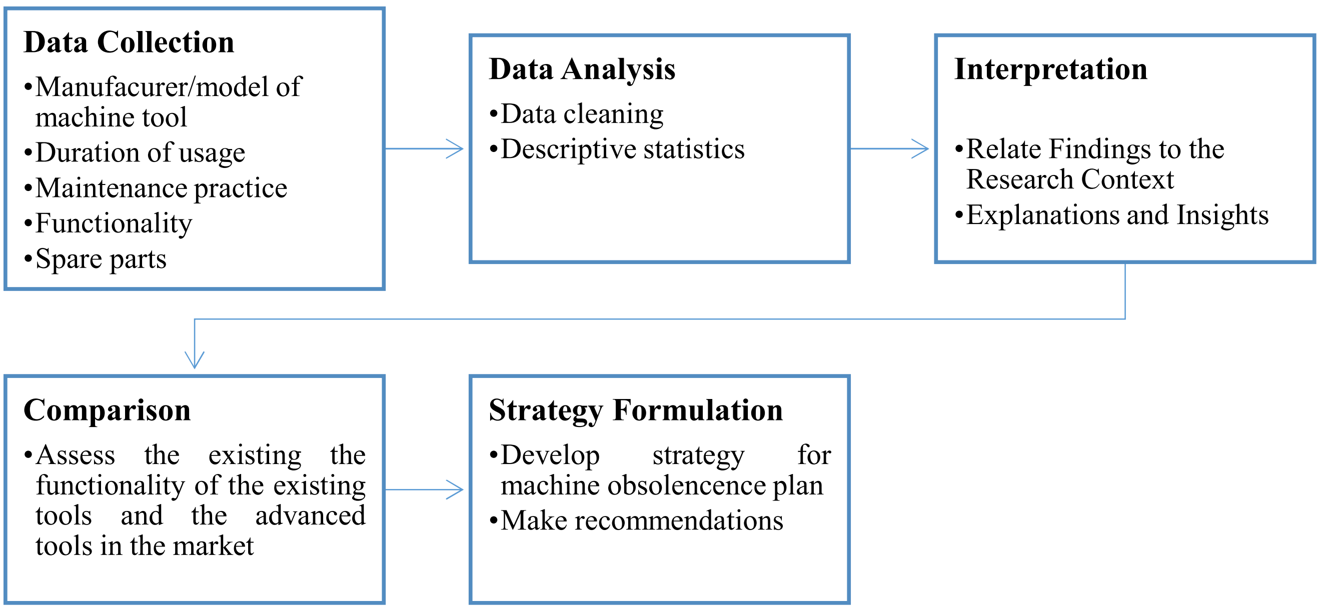

Figure 2: Research Framework

3.1 Sample Selection

Resource persons were chosen from the Faculty of Engineering Workshop at the University of Maiduguri or Ramat Polytechnic Maiduguri. These persons have extensive knowledge and experience in machine tools. By selecting these individuals, all the necessary details and insights on the machine tools were gathered.

3.2 Data Collection

A structured questionnaire was designed to gather data on various aspects related to machine tool obsolescence, including the current state of machine tools, maintenance practice, machine functionality etc. The questionnaire consists of both closed-ended and open-ended questions. The questionnaires were distributed to the selected respondents in person. Clear instructions were be provided to ensure the respondents understand the purpose of the study and how to complete the questionnaire accurately.

3.3 Strategy Development

Based on the findings, a comprehensive strategy was developed to update and upgrade the machine tool inventory. This strategy includes recommendations for financial allocation, infrastructure improvement, and awareness campaigns for technological upgradation.

4. RESULT AND DISCUSSION

Tables 1 and 2 provide an overview of the machine tools in the workshops, including their manufacturers/models, quantities, years of purchase, and functionality.

Table 1: Machine tools and their functionality in Faculty of Engineering Workshop, University of Maiduguri

S/N	Machine Name	Manufacturer/ Model	Quantity	Year of Purchase	Functionality
1	Lathe machine	Excel	2	1985	One is functional
		Harrison M250	1	1985	Not functional
		Harrison M350	2	2002	Functional
2	Milling machine	Ajax U	2	1985	Functional
		Ajax V	1	1985	Functional
3	Shaping machine	Excel	1	2002	Functional
		Ajax	2	1985	
4	Surface grading machine	Ajax	1	1985	Not functional
5	Power saw	Ajax	1	1985	Not functional
6	Radial drilling machine	Ajax	1	1985	Not functional
7	Batch drilling machine	FOBSCO	2	1985	Not functional
8	Wheel grading machine	Ajax	1	1985	Not functional
9		Bison	1	1985	Not functional
10	Cylindrical grinding machine	Myford	1	1985	Functional
11	Pillar drilling	FOBCO	2	1985	Functional
		Excel	1	1985	Functional
12	Guillotine share	Morgan Rush worth			

Table 2: Machine tools and their functionality in Faculty of Engineering Workshop, Ramat Polytechnic

S/N	Machine Name	Manufacturer/ Model	Quantity	Year of Purchase	Functionality
1	Lathe	Colchester	19	1979	18 are currently functional
		Boxford	8	1971	Not functional
2	Shaping machine	ELLIOTT	8	1979	Functional
3	Milling machine	Harrison	3		One is functional
		Downham	1	1979	Functional
4	Radial drilling machine	ELLIOTT	1	1979	Not functional
4	Power hacksaw	BEWO	3		One is functional
6	Surface grinding machine	Jones & Shipman	1	1971	Not functional
7	Sensitive drilling machine	Gate Machinery	5	1979	Not functional
8	Pillar Drilling Machine	Gate Machinery	2	1979	Not functional
9	Band saw	Gate Speedax	1	1986	Functional
10	Cupping	Bridge port	1	1999	Functional
11	Vertical boring machine	Downham	1	1979	Functional
12	Mascot	Colchester	1	1999	Functional

The majority of machine tools in the Faculty of Engineering workshop, University of Maiduguri were purchased in 1985, and in the Faculty of Engineering workshop, Ramat Polytechnic Workshop were purchased in 1979. The latest year of purchase of machine tools for the institutions 2002 and 1999 respectively, indicating that the workshop's equipment is relatively old. For instance, The Harrison M Series lathes, first acquired by the University of Maiduguri in 1985 and then 2002, have been in production for many years. The range has been the subject of continuous development and, by the mid 1990s, consisted of the established and largely unchanged M300 model together with the M350, M450 and M500. By the late 1990s the last three machines became, with alterations to centre height, bed length and specification the M390, M460 and M550 - and two newer, larger machines were introduced the M600 and M750. Today the range continues in production but fitted with variable-speed drive (though the M300 continues to be available as a geared-head model) with models numbers of: V350, V390, V460 and V550 (Tony, 2022). However, the University of Maiduguri is still stuck with the M250 and the M350 models. Similarly, the new model of Ajax milling machine has a much-improved and easier-to-operate vertical head that lacked the distinctive row of 6 push-buttons controls on the front face. At the same time a number of larger models were introduced. (Tony, 2022). Technological advancements in machine tools have likely occurred since then, with newer models offering improved features, efficiency, and precision. The presence of older machines suggests that the workshop may not have kept up with the latest advancements in the field.

The functionality data reveals that several machines, particularly those purchased in 1979 and 1985, are no longer functional. This can be attributed to various factors, such as wear and tear, lack of maintenance, or outdated technology. The non-functional machines highlight the issue of obsolescence, where older machines become less reliable, costlier to repair, or unable to meet the demands of modern manufacturing processes. Despite the presence of non-functional machines, some machines purchased in 1985 and other years are still functional. This indicates that not while these machines are technologically obsolete, they still functional. This confirms that technological obsolescence does not necessarily impose functional obsolescence. Factors like regular maintenance, sparing use, and durability of certain models can contribute to their continued functionality.

The presence of multiple manufacturers and models in the fleet of machine tools in both workshops suggests that decisions were made based on availability, budget, and specific requirements at the time of purchase. Different manufacturers may have varied approaches to technological advancements, and some models could have better long-term performance than others.

Based on the survey results that reveal the obsolescence management plan, a budget for machines, and a stock of machine components in the workshops, a further discussion on the implications for technological advancement and machine tool obsolescence can be presented.

i. Age and Technological Advancement: The reliance of the workshops on machine tools purchased primarily in in 1979 for Ramat Polytechnic and 1985 for University of Maiduguri suggests a potential gap in keeping up with technological advancements. Without a budget allocated for new machines, the workshops may be limited in its ability to acquire modern equipment that incorporates the latest technologies, features, and improvements. This can hinder the workshop's efficiency, productivity, and ability to impact students with the necessary knowledge required in engineering in the 21^{st} century.
ii. Obsolescence Management: The absence of an obsolescence management plan indicates a lack of proactive measures to address the aging and potential obsolescence of the machine tools. Without a systematic approach to monitor, assess, and mitigate obsolescence risks, the workshop may face increased downtime, higher maintenance costs, and difficulties in finding replacement parts for older machines. This can negatively impact overall productivity and competitiveness.
iii. Budget Constraints: The survey revealing no budget allocated for machines further exacerbates the challenge of technological advancement and obsolescence management. Limited financial resources can restrict the ability to invest in new, more advanced machine tools. Without a dedicated budget, it becomes difficult to plan for the timely replacement or upgrade of existing machines to keep up with academic, industry standards and advancements.
iv. Lack of Machine Component Stock: The absence of a stock of machine components indicates a potential vulnerability when it comes to machine repairs and maintenance. As machines age, they are more prone to breakdowns and require replacement parts. Without an inventory of machine components readily available, the workshops may experience prolonged machine downtime, delays in repairs, and increased costs for sourcing specific parts. This can significantly impact production schedules and overall efficiency.
v. Moreover, the minimal maintenance efforts reported in the survey contribute to the overall deterioration of the machines. Insufficient maintenance can lead to increased wear and tear, decreased performance, and a higher likelihood of breakdowns. The lack of regular inspections, servicing, and repairs can exacerbate obsolescence and significantly impact the workshop's efficiency and productivity.

Acomprehensive strategy for updating and upgrading the machine tool inventory is shown in Figure 2.

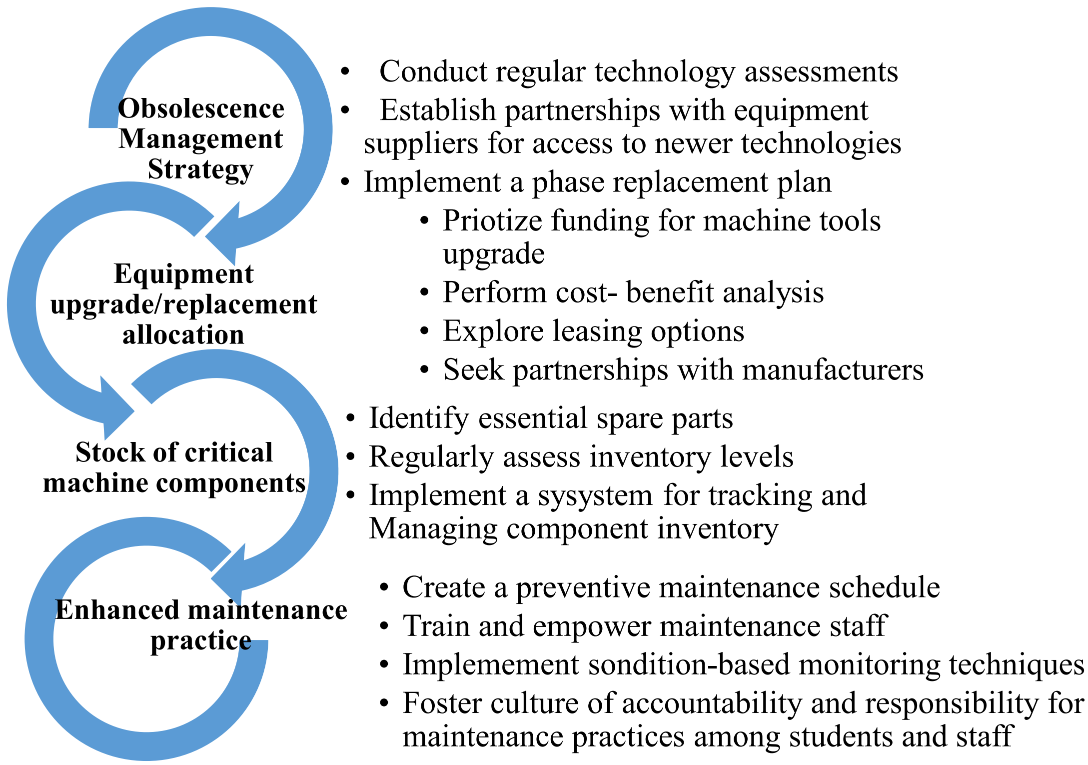

Figure 2: Machine tool inventory strategy

Obsolescence management strategy by can be achieved by regularly evaluating the existing machines in the workshop to identify those that have become outdated or technologically obsolete; collaborating with equipment suppliers or manufacturers to gain access to advanced and updated machine tools; and developing a systematic plan to replace outdated machines gradually, prioritizing those that are most critical or least efficient.

Machine tools can be upgraded or replaced through allocation of budget and resources based on the criticality and productivity of the machines, focusing on those that significantly impact the students' practical classes; evaluating the costs and benefits associated with machine tool upgrades or replacements to identify the most viable and cost-effective investment opportunities. The critical spare parts and components required for each machine in the workshop should be obtained to ensure their availability for maintenance and repairs. And lastly, a schedule for preventive maintenance activities, including regular inspections, servicing, and repairs should be developed to address potential issues and maintain optimal machine performance.

5. CONCLUSION

The following conclusions are drawn from the study:

i. The current state of machine tools in the workshops of these institutions reveals a mix of functional and non-functional machines. Machines purchased in 1979 and 1985 show a higher rate of non-functionality, indicating the impact of age and technological advancements on their reliability and performance.
ii. The key factors contributing to machine tool obsolescence in the workshops are age and technological advancement, lack of obsolescence management strategy, budget constraints, lack of machine component stock and minimal maintenance efforts.

iii. A comprehensive strategy for updating and upgrading the machine tool inventory include obsolescence management strategy, equipment upgrade/replacement strategy, stock of critical machine components and enhanced maintenance practice.

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