

Mgr Fredrick Wanyama Mumali

**A methodology for intelligent support
in the selection of manufacturing processes based on
Generalized Matrix Learning Vector Quantization neural network**

Abstract

The choice of the manufacturing process in an enterprise, as the result of the preceding managerial decision-making process, is a key prerequisite for achieving the enterprise's optimal industrial efficiency, its sustainable development, and the quality of the product offered to the market. The dissertation aims to develop and verify a methodology for intelligent support in selecting manufacturing processes based on the *Generalized Matrix Learning Vector Quantization* neural network, to alleviate subjective decision factors and leverage domain knowledge in addition to sustainability goals and the product-specific design requirements. Despite the existing body of work, there remains a lack of integrated decision support approaches that holistically consider domain expertise, sustainability goals, technological advancements, and evolving process capabilities in a dynamic manufacturing context. This dissertation seeks to fill this research gap using a two-faced approach of understanding the impact of cognitive and subjective decision factors on manufacturing process selection and developing a methodology for intelligent support in selecting manufacturing processes based on advanced neural networks. The research aims to understand and quantify how subjective decision factors, namely cognitive biases, personal preference, and groupthink, interact with domain knowledge to limit efficient manufacturing process selection using empirical evidence and to develop an intelligent methodology that leverages advanced neural network techniques to support optimal decision-making in manufacturing process selection. The research goal is achieved by investigating the negative influences of cognitive and social factors on decision quality in the selection of manufacturing processes and developing a methodology for intelligent support in the selection of manufacturing processes based on *Generalized Matrix Learning Vector Quantization* neural network. As such, the subject of the research is twofold; first, it concerns the interplay between subjective decision factors and the use of domain knowledge in manufacturing process selection, particularly in the era of Industry 5.0, where manufacturing is re-imagined with a stronger focus on human-centric decision-making. Secondly, it concerns a methodology for the intelligent selection of optimal manufacturing processes based on *Generalized Matrix Learning Vector Quantization* neural networks. In the current state of management theory and practice, decision-making is subordinated to subjective decision factors such as cognitive biases, self-interested motives, and groupthink, which suppress the use of professional domain knowledge and expertise. The existence of such a state of affairs was confirmed in this dissertation through empirical research (chapter two of the dissertation), which justified the first of the two main research hypotheses concerning the limitations of the

decision-making process in the selection of the manufacturing process. The research results show that the aforementioned subjective factors significantly deprive the managerial decision-making process of the proper use of professional domain knowledge, leading to poorer process selection and the degradation of the decision. For the purpose of justifying the second, conceptual main hypothesis of this dissertation, studies were conducted (presented in the subsequent three chapters) on the application of an enhanced *Generalized Matrix Learning Vector Quantization* neural network, which adapts to multidimensional, noisy, and heterogeneous production data, while simultaneously integrating expert knowledge to assess and select the most appropriate manufacturing processes objectively. In the first of the aforementioned conceptual research chapters, the issue of the intelligent selection of production processes using artificial neural networks, fuzzy logic, and genetic algorithms was presented. Next, the systematic examination of the *Generalized Matrix Learning Vector Quantization algorithm* with improvements and its applications for future production process selection was conducted. In the following chapters of this dissertation, the applications of *Generalized Matrix Learning Vector Quantization* for process selection with an experimental configuration were synthesized, along with an explanation of the dataset used and comparisons with conventional approaches such as *Support Vector Machine*. A detailed summary of the conclusions, findings, and areas for future research is devoted to the final part of the dissertation. The general conclusion was formulated as an observation that the generalized matrix learning vector quantization improves decision-making in the manufacturing process selection by eliminating human biases and enabling a more effective use of domain knowledge. The generalized matrix learning vector quantization model achieved one hundred percent accuracy in the selection of the manufacturing process, thus demonstrating its effectiveness in realistic scenarios. The research presented in this dissertation also proved the harmful consequences of subjective factors in decision-making on the quality of production decisions and showed that *Generalized Matrix Learning Vector Quantization* can be used as one of the possible alternatives to such biases, making decision-making more effective in the conditions of a production enterprise. In the cognitive scope of management sciences, a new data and information-based decision support method was introduced that balances subjective decision factors with objective information to make manufacturing process selection more accurate, efficient, and sustainable. With regard to future research directions on the topic of this dissertation, it was suggested to test the generalized matrix learning vector quantization model with more significant and diversified datasets and to examine its scalability and transferability value to other industrial applications.