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Abstract. The escalating demand for energy efficient motor-driven systems (EMDS) in industry together with the rapid pace of digitalization presents a significant challenge and opportunity for workforce development. We outline a novel educational approach that harmonizes an educational pathway with the specific digital competencies required for EMDS. We introduce a modular learning framework that integrates short, context-rich learning journeys with the digital skills identified as critical for EMDS, such as data analysis, system design, and optimization techniques. The program is structured using a 'metro line' concept, delivering compact, intensive modules that cover a comprehensive range of topics, from the fundamentals of electric motors to the implementation of advanced control strategies for maintenance engineers and from integrating energy-saving opportunities, regulatory frameworks, and lifecycle cost analysis for management.

By embedding the principles of nano-learning and digital badging, we aim to rapidly upskill the workforce in both generic and specialized competencies, as outlined in the Digital Skills Framework. The curriculum is responsive to industry needs, emphasizing hands-on application through collaborative workshops and real-time data analytics. The ultimate goal is to facilitate a proficient workforce capable of driving EMDS efficiency initiatives within their organizations, thereby advancing both economic and environmental objectives. By combining the novel educational model with industry-specific content, the initiative aims to foster a culture of continuous learning and improvement in the electromechanical systems domain.

Keywords: Life Long Learning, Energy Efficient Motor-Driven Systems, Skills Development

1 Introduction

The escalating demand for energy efficient motor-driven systems (EMDS) in industry together with the rapid pace of digitalization presents a significant challenge and opportunity for workforce development.

Europe aims to cut greenhouse gas emissions by at least 55% by 2030 from 1990 levels and achieve CO2 neutrality by 2050. Since 01.07.2021, EU regulation (EU) 2019/1781 mandates energy efficiency classes IE2 for motors from 0.12 to 0.75 kW and IE3 for up to 1000 kW. From July 2023, the new IE4 efficiency standard becomes mandatory for medium-sized motors between 75 to 200 kW. These regulations are expected to save 110 TWh of energy in the EU by 2030, equivalent to the electricity consumption of the Netherlands, and reduce CO2 emissions by 40 million tons annually.[1]

Digitalization introduces 'smart' applications across various industrial energy systems, among which EMDS account for a large share of industrial electricity consumption. Depending on the industry subsector, EMDS consumption can reach up to 25% of the total electricity use. Given the dominance of motors in industrial processes, improving EMDS is crucial for enhancing industrial efficiency. New regulations will boost the energy performance of new industrial motors. Despite the crisis extending payback periods by only 10%, due to long usage hours and stable electricity prices, industries are less likely to upgrade motors, focusing instead on core business and cost reduction. This is especially true in less energy-intensive industries, which still hold 70% of the sector's energy savings potential according to international literature.[2]

Finding skilled workers in digitalizing electrical motors poses a significant challenge, as such expertise is highly sought after and difficult to cultivate internally.[3] The major costs are associated with acquiring the necessary knowledge and education, rather than the technology itself. It is crucial for educational institutions to adapt to technological advancements to fill this knowledge gap. Resistance among employees to learn new digital skills and the complexity of integrating motors with digitalization present additional hurdles, particularly for smaller firms.

The results from an employer survey in the Northern Netherlands show hesitancy among employers, employees, and educational institutions regarding learning and development.[4] There is a focus on creating conditions for learning, with the expectation that learning will happen naturally, but this is not the case. Employers often lack the ability to support learning effectively, and employees may not feel confident or knowledgeable enough to take the initiative. Small and medium-sized enterprise directors struggle to develop a clear vision for development due to daily concerns. Therefore, it is crucial to set up concrete, practical, and organic support for employers and employees, emphasizing the importance of a trusting relationship. This involves long-term collaborations between support organizations (like educational institutions) and companies, using learning and development coaches, mentors, and career advisors.

On behalf of the Dutch Topsector Energy, the Digitization program, in collaboration with Dutch knowledge institutions, industry, and end-users, Royal HaskoningDHV has developed a digital skills framework for Motor Driven Systems (MDS).[5] The digital skills set for MDS is divided into technical (electrical, mechanical, digital) and non-

technical (ethical, cybersecurity, legislation) areas, with both sets needing attention in learning activities. A key role identified is the data translator, bridging the gap between IT/data technology and the EMDS domain, crucial for the success of digitalization efforts. These individuals require a blend of soft and non-technical skills, including communication, domain expertise, and project management, as well as traits like creativity and adaptability. Additionally, knowledge in legal aspects of data sharing, storage, and use, along with new European data policies, is essential for navigating the digital landscape of motor driven systems.

In shaping learning activities for skills in EMDS enhanced with digital technologies, a balance must be achieved across three key dimensions: learning levels (ranging from individual to organizational, low to high levels), the variety of learning tools (such as in-company training, webinars, courses, coaching), and the development of broad and in-depth skills.[5]

The aim of this research is to experiment with a novel modular learning framework that integrates short, context-rich learning journeys with the digital skills identified as critical for EMDS, such as data analysis, system design, and optimization techniques.

The goal is to facilitate a proficient workforce capable of driving EMDS efficiency initiatives within their organizations, thereby advancing both economic and environmental objectives. By combining the novel educational model with industry-specific content, the initiative aims to foster a culture of continuous learning and improvement in the electromechanical systems domain.

2 Methodology

The program is structured using a 'metro line' concept, delivering compact, intensive modules that cover a comprehensive range of topics, from the fundamentals of electric motors to the implementation of advanced control strategies for maintenance engineers and from integrating energy-saving opportunities, regulatory frameworks, and lifecycle cost analysis for management.

2.1 Smart Makers Academy Concept – Metro maps

The Smart Makers Academy concept was started out of the Dutch Smart Industry community in the ambition to improve the digital adoption within industry.[6] The concept distinguishes itself with its unique approach tailored for SMEs, offering short and impactful practice-oriented training that facilitates easy steps towards addressing digitalization and sustainability challenges. It utilizes nano-learning in a context-rich group environment, providing an accessible and clear curriculum visualized through a "metro map".

The metro map, with its interconnected lines and transfer stations (or nano-modules), facilitates a cohesive learning journey. Participants, like passengers, traverse through various stations (learning modules) aimed at enhancing SMEs' innovation and implementation capabilities. Each line is designed to prompt action or behavioral change, incorporating a blend of workshops, e-learnings, and experiences. A typical metro line consists of a maximum of nine consecutive sessions, each lasting up to four hours. This

educational journey not only fosters skill development but also encourages engagement in further learning, mirroring the interconnected and goal-oriented routes of a metro system tailored for professional growth in a digital age.

The program supports personal and flexible development paths for participants, culminating in certification with Open Badges. The concept of Open Badges relies on validated indicators of achievements or skills that learners can earn in various learning environments.[7] It is a digital image related to metadata that contains information defining the badge. [8] What makes the badge valuable - for both the participant and potential employers or educational institutions - is the detailed badge description. This description outlines in detail the knowledge and skills the learner has acquired and how these have been demonstrated.

2.2 Starting point: Metro line Canvas and Skills Profile Canvas

In analogy with a Business Model Canvas, the Metro line Canvas is a tool designed to map out essential aspects of a learning program, acting as a blueprint to ensure all critical facets are considered, including value propositions, resources, and key stakeholders. It starts with defining the value proposition, focusing on how the learning program adds value to learners, providers, and companies involved. The process involves brainstorming what learners will gain, the motivation behind providers offering specific skills, and how the learning program assists companies in talent development.

The Skills Profile Canvas methodically outlines the process of tailoring a skills profile derived from the Metro line Canvas. The skills profile must ensure the curriculum meets the specific needs regarding the requested knowledge, skills, and competencies. It emphasizes the importance of performance indicators for evaluating the learning journey's success and what learners are expected to achieve upon completion. Additionally, it necessitates cataloging existing skill profiles for thorough planning and understanding the necessary resources—like software, hardware, and workspaces—to facilitate an optimal learning experience. Crucially, the process involves identifying key stakeholders, including endorsers for quality validation, media for information dissemination, and rewarders who acknowledge and valorize the acquired skills, possibly converting them into job opportunities, thereby guaranteeing a focused and effective learning outcome tailored to participant needs. Finally, the Skills Profile Canvas is the blueprint for setting up the metro map.

2.3 Project partners

The development sessions were conducted under guidance of NHL Stenden University of Applied Science in collaboration with the Smart Makers Academy together with the following partners Topsector Energy, RVO, Water board Vallei & Veluwe and Network for Efficient Electrical Drive Systems.

3 Results

3.1 Metro line Canvas – Reduction Energy usage Electric Driven Systems (REEDS)

The results of the development sessions regarding the Metro line Canvas are summarized in table 1.

Table 1. Metro line Canvas – Reduction Energy usage Electric Driven Systems.

Category	Description
Partners	The metro line is developed and executed through a collaboration involving the knowledge institute (owner), a field committee of users (OEM suppliers, innovative technology companies, industry, water management, both SMEs and large enterprises).The goal is to incorporate the latest technological developments.
Topics	Covers design, usage, maintenance of energy systems, mechanical and thermodynamic aspects, sustainable maintenance, digital skills according to the DigCom Framework (including information and data literacy, communication and collaboration, digital content creation, safety, problem-solving), human skills (communication and digital reporting), installation/ verification, understanding of data/data management, and system engineering. [9]
Skills	Participants will learn to read design drawings, understand the impact of asset failure on energy consumption, explain the concept of predicting failures based on data, and apply digital visualizations for planning and executing maintenance.
Value proposition	Offers participants, companies of participants, and executing partners/educators benefits such as obtaining a network, learning flexibly, shorter time to job, lower training costs, better alignment with innovation developments, professionalization of teachers, and the necessary end qualifications.
Goal	Aimed at enabling low-threshold steps in digitalization and sustainability transitions, offering a short and practical approach suitable for SMEs, nano learning in a context-rich environment, accessible and clear offerings (metro map), personal and flexible development paths, and certification with open badges based on validated skill profiles, suitable for a skills-based labor market.
Desired reaction	Participants demonstrate skills in concrete cases, share cases.
Target group	Process operators, process/maintenance engineers, maintenance mechanics, reliability/data engineers, OEM employees, team leaders; aimed at SMEs to large enterprises in various sectors (process industry and water management).
Learning Style & Context	Effective learning occurs in a safe, comfortable environment that encourages questions and learning from mistakes, utilizes practical setups and hybrid formats for flexibility, offers responsive feedback, supports interactive sessions, and includes real-case application at participants' companies and self-study online.

3.2 Skills Profile Canvas – Metro Map: Reduction Energy usage Electric Driven Systems

Based on the Metro Line Canvas the Skills Profile Canvas was derived which leads to an initial draft for the metro map for Reduction Energy Usage in Electric Driven Systems. (figure 1) This metro map consists of four distinct metro lines, each designed for specific target groups within the organization. These lines are:

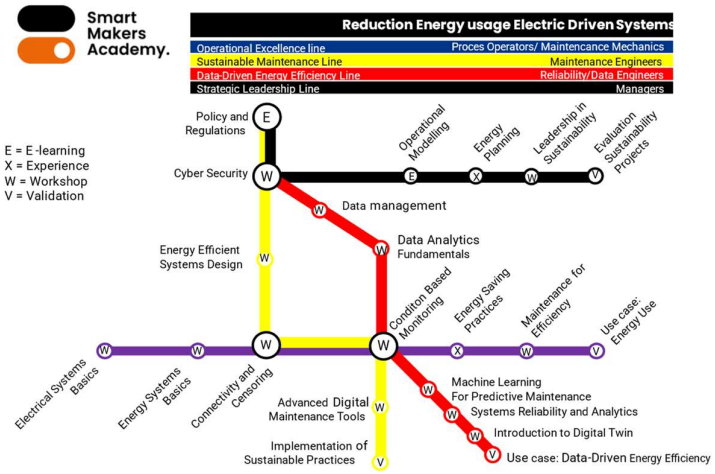
- Operational Excellence Line for process and maintenance mechanics, focusing on enhancing operational efficiencies and maintenance practices.
- Sustainable Maintenance Line for maintenance engineers, emphasizing sustainable maintenance practices and methodologies.
- Data-Driven Energy Efficiency Line for reliability/data engineers, aimed at leveraging data analytics to improve energy efficiency.
- Strategic Leadership Line for managers, designed to cultivate strategic thinking and leadership skills in managing energy reduction initiatives.

Although each line serves a specific target audience, there are overarching themes such as cyber security, policy and regulations, connectivity and censoring, and condition-based monitoring. These themes are relevant across different target groups but follow a specific continuation in the curriculum. These overarching themes are symbolized as transfer stations in the metro map.

Three different methodologies have been selected to facilitate learning: E-learning, Experience, and Workshops. The latter two are particularly suited for fostering interaction and enhancing soft skills among participants.

Finally, each metro line concludes with a validation session where participants' knowledge and competences are assessed. Assessment methods include presentations, peer reviews, or dialogic validation. Upon successful completion, participants are awarded micro-credentials, recognizing their achievements, and newly acquired skills.

Fig. 1. Metro map of Reduction Energy usage Electric Driven Systems with four metro lines regarding Operational Excellence for Process Operators, Sustainable Maintenance for Maintenance Engineers, Data-Driven Energy Efficiency for Reliability/Data Engineers and Strategic Leadership for management.



4 Conclusion

This initiative represents a pioneering approach to integrating advanced technologies in metro line development, facilitated by a partnership between a knowledge institute and a diverse consortium. It ambitiously spans a comprehensive curriculum that not only addresses technical aspects such as energy system design and maintenance but also places a strong emphasis on digital competencies and human skills.

The derived metro line map outlines a comprehensive training framework across four key roles: Process Operators/Maintenance Mechanics, Maintenance Engineers, Reliability/Data Engineers, and Management. It progresses from basic principles of electrical and energy systems to advanced skills in maintenance, cybersecurity, and data analytics, emphasizing practical applications and sustainable practices.

By promoting a learning environment that is both practical and flexible, including the use of real-case applications and online self-study, the initiative sets a new standard for professional development in the context of digital and sustainable transitions, underlined by the certification of skills in a manner that resonates with the needs of a skills-based labor market.

The forthcoming phase entails crafting a curriculum derived from the metro line concept, incorporating its designated learning outcomes. After the curriculum's establishment, the intention is to initiate the first pilot projects within the water management community in 2024. These preliminary endeavors will evaluate the curriculum's

impact, tailor it to the distinct requirements of the industry, and refine the educational strategy based on the feedback from both participants and involved parties.

This strategic educational approach equips professionals with the knowledge and tools to drive sustainability initiatives and improve energy management within their organizations, aligning workforce skills with industry needs for a sustainable future.

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