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Future Skills Taxonomies in Engineering Continuing Education Shaping Lifelong Learning: An Integration Proposal

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Abstract

With rapid advances in Industry 4.0 and 5.0 technologies, there is a growing need for a structured approach to continuing engineering education that supports lifelong learning and aligns with evolving industry demands. This paper presents an implementation proposal for a novel framework that integrates knowledge, skills, and abilities (KSA) taxonomies, predictive analytics, and best practices in curriculum development. Designed to address the unique needs of the Information and Communications Technology (INFOCOMM) workforce, which faces continuous

technological disruptions, this framework aims to provide a dynamic and adaptive methodology for educational institutions and industry professionals. This proposal outlines how a future application could facilitate the development of flexible curricula by leveraging real-time labor market data and predictive modeling to enhance workforce readiness. The framework supports active learning, hands-on methods, and customized learning paths to help professionals acquire critical future skills, such as digital literacy, creativity, and problem-solving. A hypothetical case study illustrates how the framework might function, demonstrating its potential application in aligning education with workforce demands. While this paper does not present empirical results, it establishes a structured roadmap for future implementation and validation. Planned pilot testing and stakeholder feedback collection will assess the framework's effectiveness in improving engagement, skill acquisition, and curriculum adaptability. Future research will explore its scalability to other engineering disciplines, ensuring broad applicability beyond the INFOCOMM sector. This proposal lays the foundation for a data-driven, adaptive approach to lifelong learning in engineering education by providing a structured heuristic model for curriculum planning.

Introduction

The swift advancements in Industry 4.0 technologies and the advent of Industry 5.0 signify a profound transformation in technological innovation and its application across diverse domains, with significant implications for the engineering and information and communications technology (INFOCOMM) sectors. Industry 4.0 has been characterized by integrating technological systems that have revolutionized traditional manufacturing and service models by enabling unprecedented levels of automation and digital connectivity [1, 2]. Meanwhile, Industry 5.0 builds on these advancements, emphasizing human-centric approaches, sustainable practices, and human-machine collaboration to address societal challenges [3, 4].

In the engineering and INFOCOMM sectors, these advancements have created a pressing need for professionals to acquire new skills to adapt to technological disruptions and changing market demands. Digital transformation and automation are changing the nature of work, requiring engineers to possess not only technical skills but also adaptability, problem-solving abilities, and digital literacy [5, 6]. Integrating advanced technologies such as artificial intelligence-specific examples of network and boundary crossing within institutionsence (AI), robotics, and augmented reality into INFOCOMM workflows has further intensified the need for continuous upskilling [7, 8].

Continuing engineering education (CEE) is critical in equipping professionals with the skills required to navigate this dynamic landscape. However, traditional approaches to curriculum design often fail to keep pace with rapid technological advancements and changing industry demands. Existing educational models struggle to address the gap between the skills provided by academic programs and those required in the workforce, resulting in a skill mismatch [9, 10]. This misalignment highlights the need for innovative frameworks integrating data-driven strategies to align educational content with future skill requirements.

Future skills, including digital literacy, creativity, and critical thinking, are vital for the INFOCOMM workforce to remain competitive and adaptable in an environment characterized by ongoing technological disruptions [11, 12]. However, designing curricula that effectively

incorporate these skills poses several challenges. Educational institutions must address the complexities of forecasting skill demands, integrating interdisciplinary knowledge, and ensuring that learning outcomes remain relevant over time [13, 14].

To address these challenges, this paper presents an implementation proposal that integrates knowledge, skills, and abilities (KSA) taxonomies into curriculum development. The proposed approach provides a structured roadmap for future applications that leverage predictive analytics and KSA analysis to guide the design of data-driven curriculum planning and enhance professional development programs. Rather than introducing an already validated model, this work establishes a foundation for future empirical research. The structured approach outlined in this paper facilitates the adaptation of the curriculum to respond to technological disruptions proactively, ensuring that professionals in the engineering and INFOCOMM sectors are prepared to meet the demands of Industry 4.0 and 5.0. This integration of KSA taxonomies uniquely aligns educational content with industry needs while fostering lifelong learning and workforce adaptability [5, 15, 16].

The subsequent sections detail the framework's conceptual structure and practical feasibility, as a potential strategic approach to integrating KSA taxonomies into curriculum development, leveraging predictive analytics for data-driven planning. While the paper does not yet present empirical findings, the implementation roadmap seeks to address the evolving skill demands of Industry 4.0 and 5.0 while also enhancing lifelong learning opportunities in engineering education. The study also discusses the framework's ability to bridge the gap between traditional educational approaches and the dynamic requirements of the INFOCOMM workforce, fostering a more adaptable and future-ready professional landscape.

Overview

This section provides a theoretical foundation for exploring dynamic taxonomic frameworks based on KSAs, highlighting their ability to evolve with technological disruptions while fostering lifelong learning and workforce adaptability. It contextualizes how such frameworks could be applied in future curriculum development efforts. The discussion outlines the application of these frameworks in curriculum development by presenting current processes, best practices, and innovative course designs that align with the changing demands of modern industries. It also emphasizes the importance of modular, interdisciplinary, and industry-aligned approaches in fostering professional growth and ensuring the relevance of engineering education.

Dynamic Knowledge, Skills, and Abilities Taxonomies Frameworks in Continuing Engineering Education

Dynamic taxonomy frameworks emerge as a critical response to the demands of Industry 4.0 and 5.0, particularly in the engineering and INFOCOMM sectors. These frameworks aim to structure and organize KSAs in ways that align with industries' current and future needs, facilitating continuous adaptation and lifelong learning for professionals. Unlike static approaches to skills categorization, dynamic taxonomies are designed to evolve with technological advancements and changes in the labor market [11, 12].

The dynamic taxonomy framework explored in this study, called ShapingSkills [17], is based on established models such as the World Economic Forum's (WEF) Future Skills Taxonomy [18], Nesta's innovation-driven skills frameworks [19], and Singapore's SkillsFuture initiative [20], which emphasizes modular and industry-relevant learning pathways for continuous skills upgrading. These models provide a basis for identifying essential skills while stressing the importance of adaptability and forward-thinking strategies in skills development.

Unlike traditional frameworks that often focus on static lists of competencies, dynamic taxonomies have the potential to leverage predictive analytics and real-time data to identify emerging skill demands. For example, while traditional taxonomies may classify skills based on predefined categories, dynamic models could integrate labor market analysis, job advertisements, and industry reports to refine their classifications continually [13, 15]. This adaptive capacity is particularly relevant to the information and communications sector, which faces ongoing technological disruptions and rapidly evolving job roles [5, 9].

The proposed dynamic taxonomy framework is conceptualized as a tool to address the critical KSAs gap in the INFOCOMM sector by systematically identifying and prioritizing the KSAs required to close the gap between current educational offerings and industry needs (see an occupation KSAs list from ShapingSkills in Figure 1). Along with this, frameworks such as the SkillsFuture initiative have demonstrated the effectiveness of modular, competency-based education in supporting workforce readiness [20]. Similarly, the framework application outlined in this study highlights the theoretical use of active learning and experiential approaches to promote the development of digital literacy, problem-solving, and creativity in engineering professionals [10, 14].

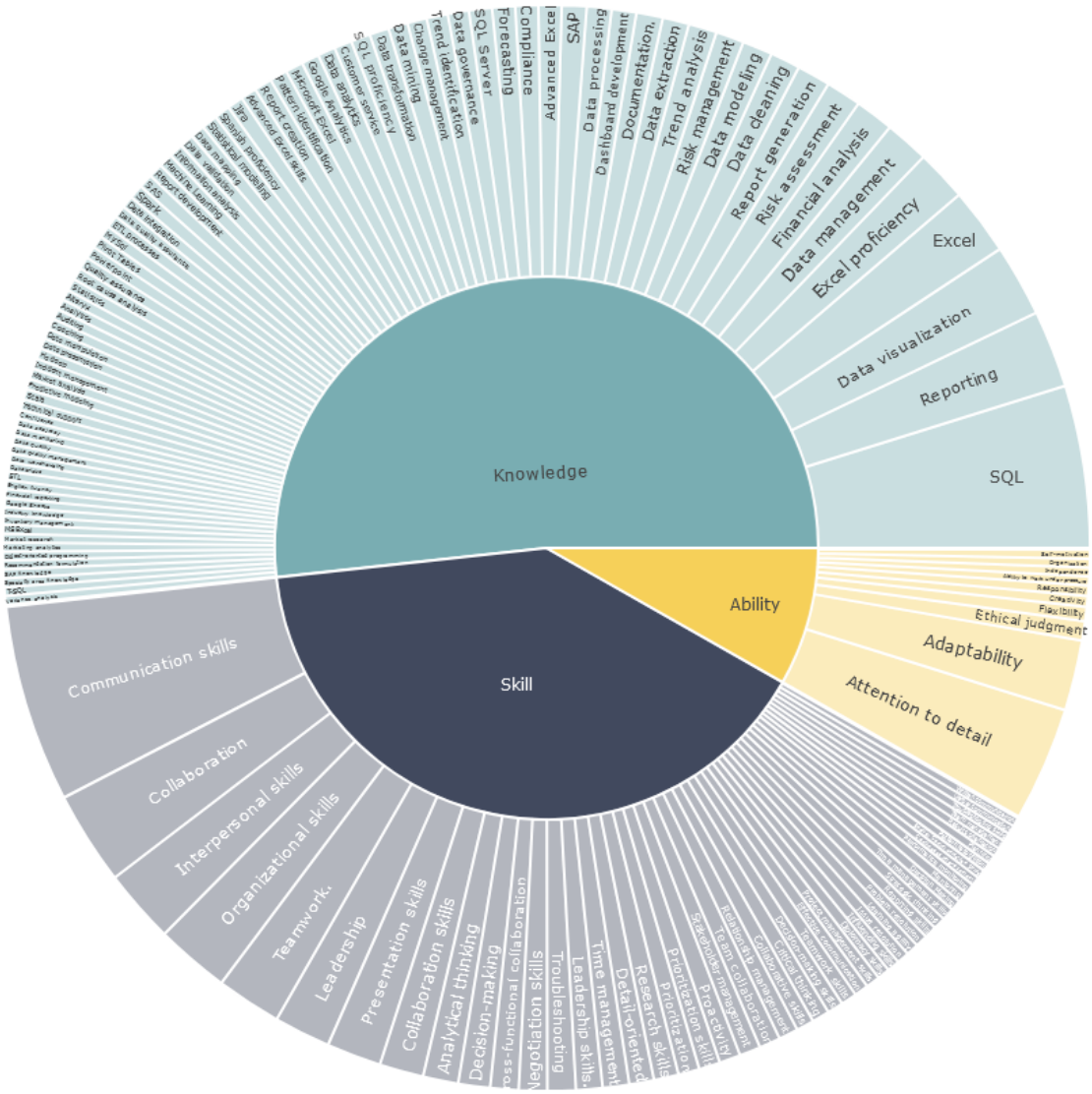

Figure 1: One of the charts provided by ShapingSkills to explore the different KSAs related to the Data Analyst occupation [21].

In addition to addressing the KSAs gap, dynamic taxonomies are pivotal in enabling continuous adaptation to Industry 4.0 and 5.0 technologies. By incorporating predictive analytics, these frameworks support the iterative updating of curricula to reflect the latest technological advancements, such as artificial intelligence, robotics, and augmented reality [1, 2]. Furthermore, their integration into Continuing Engineering Education (CEE) programs ensures that professional students remain competitive and well prepared for emerging industry challenges [11, 16].

Through a structured approach, dynamic taxonomy frameworks bridge the gap between theoretical education and practical industry requirements. They offer a scalable and adaptable solution to align curriculum development with the future skills landscape, enabling professionals in the engineering and INFOCOMM sectors to thrive in an era of constant technological

innovation and disruption [4, 12].

Applications for Curriculum Development in Continuing Engineering Education

CEE has the potential to be at the forefront of addressing the rapidly changing demands of Industry 4.0 and 5.0. As industries evolve, so must educational curricula, ensuring they remain relevant and responsive to technological advances and workforce needs. This requires the integration of proposed innovative frameworks, dynamic taxonomies, and industry-aligned practices into the development of engineering courses and programs.

CEE curriculum development traditionally involves stakeholder engagement, competency mapping, and iterative design processes. These approaches align educational outcomes with accreditation standards and industry requirements, ensuring students have the technical and professional competencies necessary for their careers [22, 23]. However, these traditional methods often struggle to keep pace with rapid technological advances and changing industry demands.

Several frameworks have been developed to support curriculum design, emphasizing adaptability, industry relevance, and lifelong learning. The WEF highlights critical future skills such as problem-solving, creativity, and collaboration, which are essential to navigating the complexities of modern industries [18]. The Nesta framework emphasizes fostering creativity and interdisciplinary skills to prepare students for innovative roles in evolving sectors [19]. Singapore's SkillsFuture initiative demonstrates the value of modular, competency-based learning, promoting ongoing professional development and alignment with industry needs [20].

Dynamic taxonomies, such as the ShapingSkills framework, provide a theoretical solution to curriculum design challenges. These taxonomies could integrate real-time labor market analytics with KSA data to inform curriculum development. In the proposed approach, this hypothetical integration ensures that educational programs remain responsive to industry trends while addressing the critical skills gap in sectors such as INFOCOMM [12, 24].

Examples of innovative course designs further highlight the potential of aligning curricula with industry needs. Various educational models that have come into vogue today, such as virtual and hybrid classes, combined with gamification techniques, have been shown to improve student engagement and learning outcomes in engineering courses [25, 26]. Similarly, virtual and augmented reality technologies have been successfully deployed to create immersive learning environments, enhancing the practical application of theoretical concepts [27, 28]. Modular courses, such as those promoted by SkillsFuture, allow students to acquire specific skills incrementally, ensuring adaptability to evolving job roles and technological disruptions [20].

Best practices in engineering course design include the integration of active learning methodologies, collaboration with industry, and interdisciplinary content. Active learning approaches, such as project-based learning and case studies, foster critical thinking and practical problem-solving skills [10, 29]. Collaboration with industry ensures that course content is aligned

with real-world challenges, enhancing its relevance and impact [5, 9].

The ShapingSkills dynamic taxonomy framework [17], which forms the foundation of this implementation proposal, builds on these practices by incorporating predictive analytics to anticipate future skill demands. This data-driven approach is intended to facilitate the design of courses aligned with current industry requirements while preparing students for future challenges and offers a structured model for future empirical evaluation. By integrating KSAs into curriculum development, this framework could provide a solid foundation for addressing the complexities of Industry 4.0 and 5.0, ensuring the long-term relevance and effectiveness of future CEE programs [15, 16].

Methodology

This section presents the conceptual foundation for developing the proposed framework, which integrates the KSA taxonomies into the curriculum profile for CEE. The methodology outlines a multi-stage theoretical approach designed to assess the need for a curriculum profile, explore the implications of integrating the KSA taxonomies, and propose an initial implementation strategy. Since this is an implementation proposal, no empirical studies or validations have been conducted, and future work will focus on testing its effectiveness.

The first step in this conceptual framework involved assessing the need for a curriculum profile in CEE. A thorough analysis of the existing challenges to align educational programs with rapidly evolving industry requirements was carried out, particularly in the context of Industry 4.0 and 5.0. This assessment draws upon frameworks such as SkillsFuture [20], Nesta [19], and WEF [18], which emphasize the importance of dynamic and modular learning paths. The review of these frameworks provides a basis for integrating taxonomies in curriculum development.

Subsequently, a preliminary exploration of key objectives was defined. This step identified theoretical key metrics to assess the potential impact of integrating KSA taxonomies into curriculum development. These anticipated metrics included adaptability to industry needs, the proposed effectiveness of predictive analytics in curriculum design, and the expected improvement of lifelong learning pathways [12, 15]. While these metrics were identified as relevant for future validation, no empirical data has been collected in this study.

Then, a state-of-the-art review was conducted to examine existing KSA frameworks, curriculum development methodologies, and applications for continuing professional development. This review employed the PRISMA methodology [30] to ensure a systematic and transparent synthesis of the relevant literature. The analysis identified gaps in current research, such as the limited use of predictive analytics and the absence of frameworks tailored to the information and communications sector [13, 19].

The conceptual analysis highlighted the theoretical benefits of leveraging dynamic taxonomies for curriculum profiling, including better alignment with industry demands, supporting interdisciplinary learning, and promoting lifelong learning opportunities [5, 10]. These benefits remain hypothetical and require future testing to validate their effectiveness in practice.

Based on this analysis, an initial implementation proposal was developed. The framework merges the proposed functionalities of ShapingSkills [17] with established curriculum profiling

approaches, creating a preliminary strategy for designing adaptable and future-ready curricula. At this stage, the integration remains conceptual, and practical testing will be required in future studies. This paper references different frameworks and methods [13, 31, 32] to guide the integration process, ensuring potential scalability and alignment with institutional goals.

The implications of this proposal are explored theoretically, focusing on its potential to transform curriculum design. These include promoting innovation in educational methodologies, addressing the skills gap in the information and communications sector, and enhancing the capacity of institutions to respond to technological disruptions [11, 16].

Finally, directions for future research are outlined. Emphasis is placed on the importance of empirical validation through case studies and pilot implementations, as well as the need for longitudinal studies to assess and refine the effectiveness and feasibility of the proposed framework in real-world educational settings.

Implementation Proposal

The dynamic nature of the INFOCOMM sector requires individuals and institutions to continually adapt to changing labor market demands. Current educational frameworks often provide foundational KSAs but lack mechanisms to align with ever-updating labor market requirements dynamically. The proposed ShapingSkills framework is conceptualized as a transformative tool, enabling individuals and academic institutions to align skills and curricula within CEE with anticipated real-time occupational needs. By leveraging its theoretically defined data-driven taxonomy, the framework enables users to identify skills gaps, suggest customized training paths, and optimize academic offerings for industry-specific roles.

This section presents a conceptual implementation proposal within the proposed ShapingSkills framework, intending to hypothetically improve both individual skills assessments and institutional curriculum planning within CEE.

Customized KSA Assessments for Individuals and HR Recruiters

A proposed enhancement to the conceptual ShapingSkills framework includes new functionality that could allow individuals and Human Resources (HR) recruiters to input current professional or candidate profiles (see Figure 2 for an example). This feature is designed to analyze these profiles against ShapingSkills' proposed dynamic KSAs data for specific occupations within the INFOCOMM sector. The system is intended to generate a detailed analysis, including the KSAs the individual already possesses, those yet to be acquired, and corresponding KSAs gaps (see Figure 3 for an example). This analysis is projected to be based on real-time labor market trends and occupational requirements. To address identified gaps, the system is expected to provide practical suggestions for upskilling or reskilling, such as offering training options through specialized educational platforms.

A hypothetical example of applicability is as follows: A mid-sized INFOCOMM company looking to address the KSAs gap in its workforce related to emerging technologies such as artificial intelligence and data analytics might use this proposed application if implemented within the ShapingSkills framework. The company could feed its employees' profiles into the

system, which would theoretically analyze them against dynamic labor market data. The analysis is expected to identify critical competencies and skills that employees lack and could recommend specific training programs offered by platforms such as Coursera [33] or edX [34]. For example, an employee looking to move into a data analytics role could potentially be guided toward a specific certification course in Python programming. While this functionality is outlined as part of the proposal, real-world validation of its effectiveness is beyond the scope of this study.

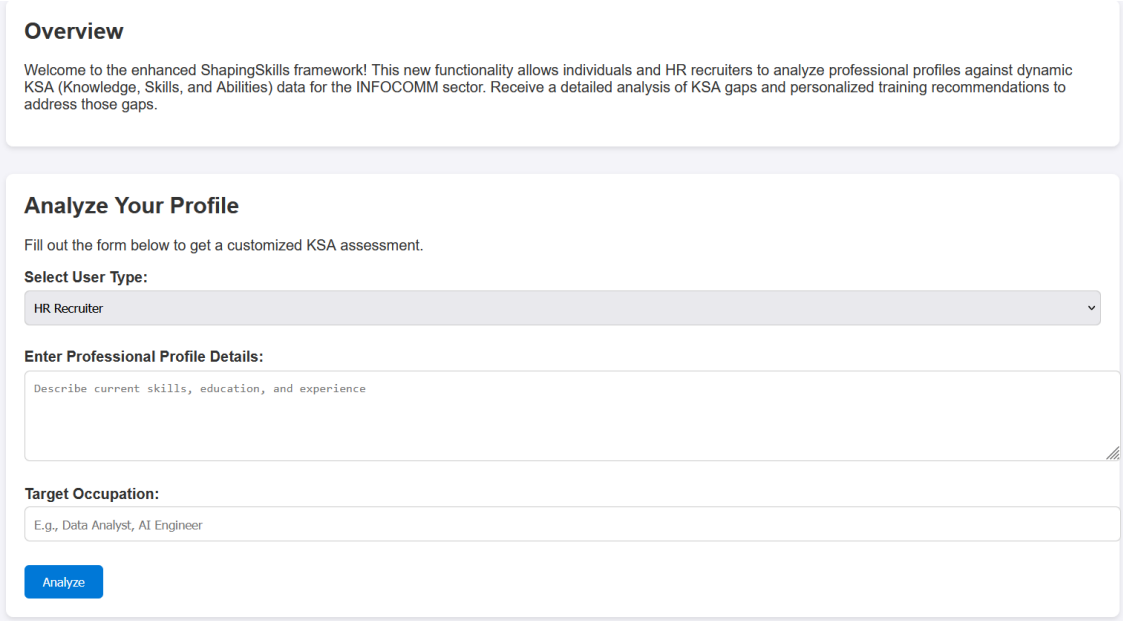

Figure 2: Example mockup illustrating individuals/HR recruiters' potential implementation proposal inputs (created using "Website Mockup Builder" [35]).

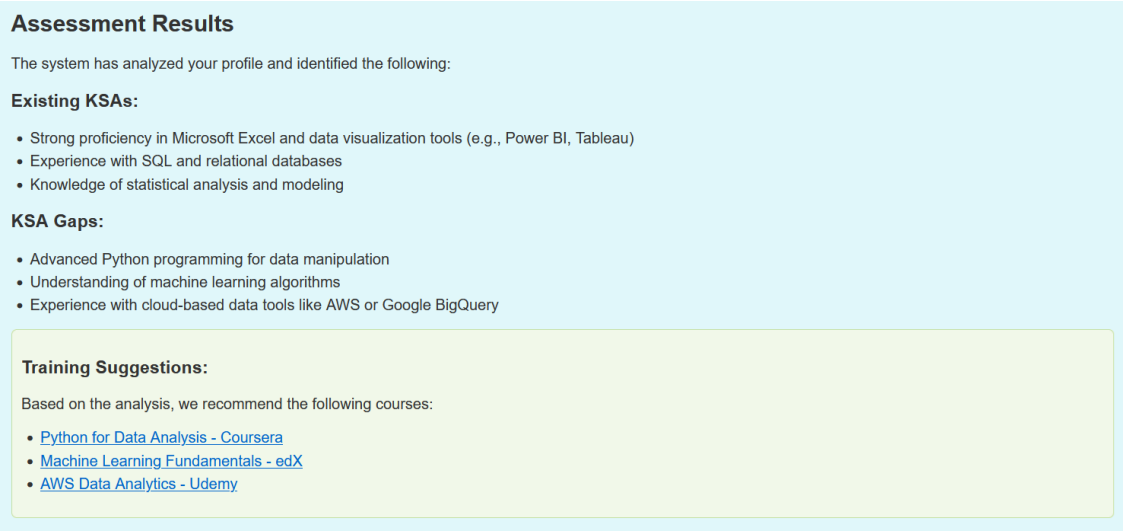

Figure 3: Example mockup illustrating individuals/HR recruiters' potential implementation proposal analyzed output (created using "Website Mockup Builder" [35]).

Curriculum Optimization for CEE Academic Institutions

For CEE academic institutions, the proposed ShapingSkills framework is envisioned to offer a specialized tool to assess the professional KSAs provided by their current curricula. Institutions could enter specific occupations or career paths they wish to address (see Figure 4 for an example). The system is designed to analyze the alignment of their educational programs with labor market demands (see Figure 5 for an example). The framework expects to identify occupations fully covered by the professional skills and competencies they currently offer and those where gaps still exist. Lists of KSA recommendations could then be provided to fill the identified gaps based on the occupations for either curriculum adjustments or enhancements, ensuring that programs remain relevant and responsive to industry needs.

This proposed functionality is significant for engineering and INFOCOMM-related disciplines, where technological disruptions are frequent and impactful. By aligning curricula with real-time market data, CEE institutions could proactively adapt their offerings, equipping students with the skills required for emerging roles. Integrating such tools could potentially promote a collaborative approach between academia and industry, ensuring that educational programs address current and future skill demands.

Continuing with the hypothetical example presented in the previous subsection related to the company looking to address the KSAs gap in its workforce, the company could collaborate with a local university that offers a continuing education program. Using this proposed application implemented in the ShapingSkills framework, the university could assess its curriculum against the competencies needed for INFOCOMM positions. The analysis is expected to reveal gaps in digital literacy and AI-related skills. Based on these insights, the university might update its course offerings, introducing machine learning and cloud computing modules, ensuring its graduates are better prepared to meet industry demands. It is important to note that this example is purely illustrative and does not reflect an actual implementation.

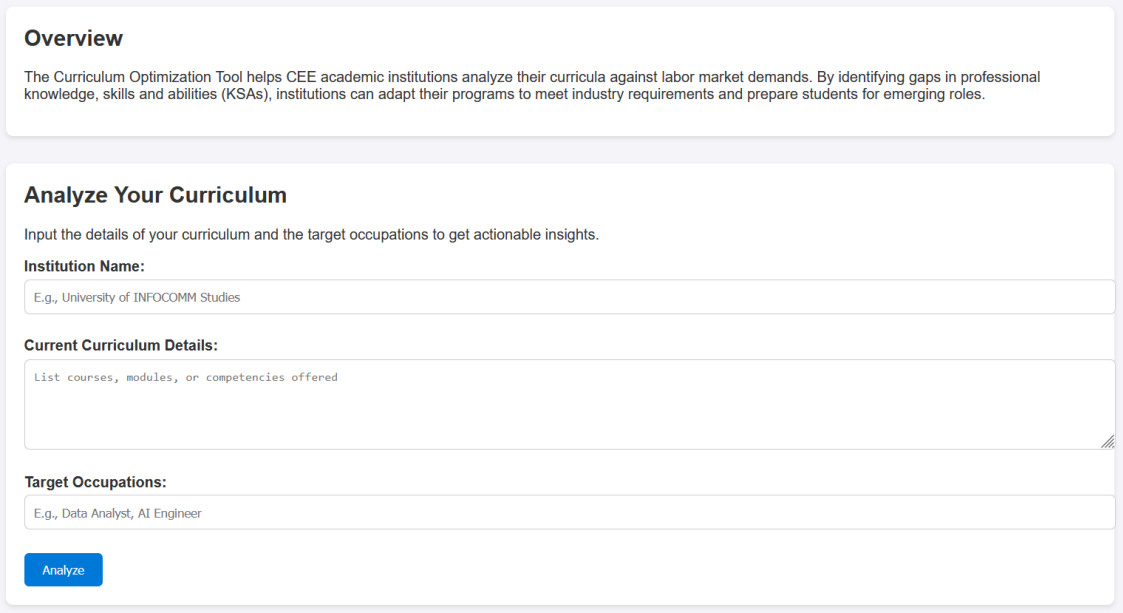

Figure 4: Example mockup illustrating CEE Academic Institutions potential implementation proposal inputs (created using "Website Mockup Builder" [35]).

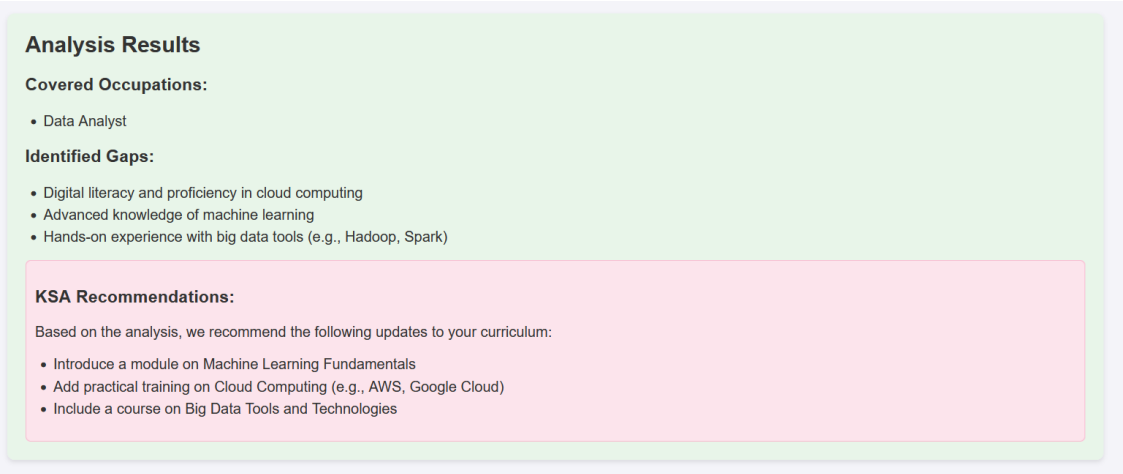

Figure 5: Example mockup illustrating CEE Academic Institutions potential implementation proposal analyzed output (created using "Website Mockup Builder" [35]).

Initial Implementation and Expected Benefits in the INFOCOMM Sector

The proposed initial implementation of these functionalities within the ShapingSkills framework is expected to focus on the INFOCOMM sector, which is characterized by rapid technological advancements and dynamic labor market demands. Since this study is limited to an implementation proposal, actual pilot testing and validation will be addressed in future research.

Once implemented and tested, researchers could evaluate the framework's ability to identify skills gaps and suggest action pathways for skills upskilling and reskilling would be assessed. By leveraging the dynamic ShapingSkills taxonomy, the framework could provide accurate and actionable insights that align individual and institutional efforts with real-time labor market trends. The specific application in the INFOCOMM sector is expected to ensure relevance to one of the fastest-evolving domains, laying the groundwork for broader adoption in other industries.

The proposed enhancements also aim to improve the potential accuracy of curriculum profiles, which could enable individuals and institutions to make informed decisions about their educational and career paths. This initiative is intended to foster stronger connections between academic programs and the labor market, improving workforce readiness and adaptability. Furthermore, by integrating predictive analytics and dynamic taxonomies, this proposed implementation is designed to ensure the long-term relevance and responsiveness of educational offerings amid ongoing technological disruption. If successfully implemented and validated, the ShapingSkills framework could potentially contribute to bridging the gap between academia and industry in an era of rapid change.

Expected Results and Discussion

Implementing this proposed functionality within the ShapingSkills framework has the potential to yield significant benefits in aligning curriculum design and professional development with the changing demands of Industry 4.0 and 5.0. By leveraging theoretically defined dynamic KSA taxonomies and predictive analytics, this framework is designed to help address critical gaps in CEE, pending future validation. Expected outcomes if implemented successfully include increased accuracy in curriculum profiling, better alignment with industry requirements, and facilitation of lifelong learning pathways. These outcomes are projected to improve workforce readiness and adaptability, particularly in sectors such as INFOCOMM, where rapid technological advancements and dynamic labor market demands prevail [11, 12].

The design and development of this proposed framework aim to actively engage CEE human resources professionals and academic institutions seeking to leverage real-time labor market insights. The integration of new upskilling and reskilling pathways, linked to the framework's potential ability to suggest targeted educational interventions, could position it as a transformative tool to foster innovation in CEE curriculum planning [15]. However, no implementation or validation has been conducted yet, and future work will explore the feasibility of these functionalities.

Theoretical challenges that could arise in the implementation include ensuring the accuracy and timeliness of labor market data, as inconsistencies in data sources could affect the reliability of KSA recommendations. Engaging diverse stakeholders, including human resources professionals, academic institutions, and training providers, could present coordination challenges [9]. Furthermore, adapting the framework to accommodate diverse industries and regions with distinct labor market dynamics is anticipated to pose scalability issues [5].

To address these challenges in future implementation, robust data validation protocols would need to be established, and partnerships with trusted data providers would be required. Future research

should explore the feasibility of stakeholder engagement through pilot programs or workshops. Modular components could be developed within the framework to enable customization for different industries and regions. Additionally, ensuring that any developed tools remain accessible and user-friendly would be crucial in overcoming potential adoption barriers.

The ShapingSkills framework is designed with the potential to have significant implications for curriculum design and professional development. The framework could enable institutions to proactively update their educational offerings by providing real-time insights into labor market trends, ensuring alignment with industry demands. This proposed responsiveness aims to support the development of modular and interdisciplinary curricula that foster critical future skills [10, 14]. For individuals, this framework is intended to offer a structured method for identifying skills gaps and guiding reskilling efforts, though this requires further empirical validation. By hypothetically identifying specific skills gaps and suggesting action pathways to upskill or reskill, it could enable professionals to navigate dynamic labor markets effectively, in line with the goals of promoting lifelong learning and workforce adaptability, particularly in technology-intensive sectors such as INFOCOMM [15].

The broader implications of the proposed application for the framework are also subject to further exploration, particularly its adaptability beyond the INFOCOMM sector. Future research will be needed to assess its scalability to other industries, as this proposal remains conceptual rather than an actively tested solution. If validated, the framework could serve as a model for addressing sector-specific skill demands in various industries, ultimately contributing to a more adaptable and future-ready workforce.

Conclusions and Future Work

This article presented a conceptual proposal for an enhanced application within the ShapingSkills framework, intending to improve curriculum planning and align CEE programs with the rapidly evolving demands of Industry 4.0 and 5.0. By leveraging a theoretical approach using dynamic KSA taxonomies and predictive analytics, this proposal aims to provide a potential strategy for addressing critical gaps in curriculum development and professional training, particularly within the INFOCOMM sector.

The proposed application conceptually outlines two main functionalities, focusing on helping individuals and human resource professionals identify KSA gaps, providing theoretical pathways for KSA improvement and reskilling, and supporting academic institutions in aligning their curricula with anticipated labor market demands. This proposed two-pronged approach is intended to bridge the gap between academia and industry, fostering stronger connections and ensuring that educational programs remain relevant, adaptable, and impactful in preparing professionals for future challenges.

The future implementation of these functionalities could bring valuable insights, including more accurate curriculum profiles, improved workforce preparation, and the promotion of lifelong learning pathways. If validated, the framework could support modular, interdisciplinary, and industry-aligned course designs, positioning it as a valuable tool in CEE curriculum planning. Furthermore, by proposing the integration of real-time labor market information and suggesting pathways to connect practical training opportunities, this application Hypothetically explores the

potential to empower both individuals and institutions to adapt to technological disruptions and changing industry needs effectively.

Since this study is limited to an implementation proposal, future research should validate its assumptions and test its feasibility. This includes exploring pilot studies, prototype development, and stakeholder engagement to assess whether the proposed framework can effectively address skills gaps and align curricula with evolving industry needs. Metrics such as user satisfaction, alignment of KSAs with labor market demands, and the effectiveness of suggested training pathways should be evaluated in subsequent research.

Furthermore, future research should investigate the potential scalability of this proposal to other industries and sectors. Whether the framework can be adapted for broader applications beyond the INFOCOMM sector will require further analysis, including assessments of regional and industry-specific labor market variations. Long-term studies should assess the framework's real-world impact on career development, curricular innovation, and workforce adaptability.

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