Board 67: A guide for Generation Z students to meet the Future Skills requirements of Industry 4.0

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A guide for Generation Z students to meet the Future Skills requirements of Industry 4.0

Abstract

The future characteristics of the work, workplace, and workforce in Industry 4.0 are unpredictable, as are the *Future Skills* that Generation Z workers will need in the coming years. International reports by the World Economic Forum and the Organization for Economic Cooperation and Development suggest that this situation will affect resolving urgent societal needs due to the unknown impact of skills mismatch and lead to potential workforce talent shortages. There are two latent challenges to face the disruptive changes of Industry 4.0 that show the urgency to make the training of Generation Z students more flexible in *Futures Skills*. The first is that most of the curricular programs of Higher Education Institutions continue to have a strong predominance of "silo-ism" thinking, with a rigid degree of specialization and a marked differentiation of disciplines. The second is that the current skills frameworks are static taxonomies that cannot explain how to make the necessary adjustments so that Higher Education Institutions can train students in the innovative and more efficient processes, products, and services required by Industry 4.0. This Work-in-Progress study aims to design a dynamic model of the skills taxonomy of Industry 4.0 on an open-source, flexible, and updatable platform. The platform, driven by Machine Learning tools, will be based on *Futures Studies* to forecast labor market requirements. The system will use information from the ESCO (European Skills, Competences, and Occupations), the O*NET (Occupational Information Network) frameworks, and the Strategic Intelligence platform of the World Economic Forum. The *Future Skills* considered in the study are related to Subject and individual development skills (self-efficacy, self-initiative, self-management, and autonomous learning competence); Object-related skills (tolerance for ambiguity, digital literacy, critical thinking, and creativity); and Organization-related skills (communication and cooperation competence and future mindset). Preliminary findings show that the Dynamic Model can serve as an international reference guide for designing the 2030 educational approaches of active and experiential learning in Higher Education Institutions.

Keywords: Educational Innovation, Future Skills Framework, Generation Z, Industry 4.0, Machine Learning, Higher Education.

Introduction

When we talk about occupation, job, work, or career, we talk about the activities that human beings do to obtain an income. In organizational sciences, Oldham and Fried recapitulated the research and theory of work from its beginnings (between the 30s and 50s) [1]. The authors explained the generation of concepts such as motivation-hygiene theory and job characteristics theory. In addition, they investigated the factors that generated intrinsic motivation in workers and their outcomes. The authors also mention that new perspectives have joined the research topic, such as worker personality, career stage, physical and organizational context (workplace), uncertainty, and interdisciplinarity. Finally, they concluded that better-designed jobs contribute to employee well-being and effectiveness. Recent studies have focused on other effects of work, in addition to the traditional ones (satisfaction and performance), such as creativity, health, and well-being, teamwork, which have led employees to take the initiative in customizing their work [2]–[4]. Furthermore, technological advances, together with multiculturalism and new workplaces (home office, urban hubs), have generated changes in the level of freedom and autonomy of workers that involve generational differences and transformational changes in the type of leadership. Therefore, to jump from the economics of industrialization to the high-tech economy, it has been said that stakeholders must now invest in people's skills [5]. A new stage in industrial production: Industry 4.0 incorporated technologies that quickly permeated in the form of disruptions such as cloud computing, the internet of things, big data, and artificial intelligence, which currently allow the fusion of the virtual and physical world and mark the advent of intelligent manufacturing systems [6]. Since 2000, these technologies, mainly related to digital technology and biotechnology, propitiate the creation of new jobs requiring a highly skilled workforce, mostly holding a college degree in STEM. Several crucial questions have arrived: How can education sectors and industries work together to cope with technological advances since many companies change so slowly to adapt to technologies? How to avoid challenges in matching employees' skills with productivity? Which new jobs are necessary to create in those emerging fields? [7]. Technology advancement has made its use in educational systems critical to leverage its potential in fostering an attitude of rethinking skills and pursuing lifelong learning. In addition to increasing global and collective possibilities, digitalization has brought a more volatile, complex, and uncertain world in which those who adapt, are slow to complain, and are open to change will succeed [8], [9]. Various organizations highlight a series of skills as those necessary to succeed in Industry 4.0 due to critical technologies, such as cloud computing, mobile computing, modularization, additive manufacturing, robotics, and extended reality, that have reached maturity or are in their formative stages [10]. Other Industry 4.0 keywords are human-machine collaboration, equipment integration, IoT, big data, cloud, simulations and prototypes, 3-D printing, extended realities, cyber security, sustainability, economic sustainability, process safety and environmental control, virtualization, service orientation, and environmental protection [6].

The 21st century has developed business models that cause relevant social changes. The collaborative economy, on which companies such as Uber or Amazon are based, comprises companies that don't produce goods and services but link providers with users. The consequence of this collaborative economy is that labor is hired by imitating the same structure. Several companies use the freelancer model to satisfy the demands of consumers that change systematically. In turn, generation Z prefers this model that doesn't involve a long commitment to a company. These changes will impact on the fact that by 2030 half of the world's workforce will be contingent workers (the gig economy). There are two key parameters to design Jobs 4.0: they must be mindful (increase cognitive engagement) and meaningful work (impactful for business to also have a high social impact). These two aspects of work design were already gaining attention before the pandemic and will be more critical as we think of work in a post-pandemic world [11]. According to the OECD report, 40% of employers in G20 countries report difficulties finding the right people to fill jobs [12], [13]. One of the reasons could be that 40% of the basic skills of today's workers will change in the next five years; therefore, 50% of all employees will need training and updating by 2025. Future jobs and workplace features in Industry 4.0 are volatile and unpredictable, and so are the future skills that workers will need in the coming years. As a result, solving the urgent needs of society is hampered by the unknown impact of Industry 4.0 on the skills, competencies, and jobs and the corresponding talent shortages of the workforce.

The *Future Skills* considered in the study are related to the following: Subject and individual development skills (self-efficacy, self-initiative, self-management, and autonomous learning competence) [14]; Object-related skills (tolerance for ambiguity, digital literacy, critical thinking, and creativity) [15], [16]; and Organization-related skills (communication and cooperation competence, future mindset). This Work-in-Progress study aims to design a dynamic model of the skills taxonomy of Industry 4.0 on an open-source, flexible, and updatable platform. The platform, driven by Machine Learning tools, is based on *Futures Studies* strategies to forecast labor market requirements, using information from:

- ESCO (European Skills, Competences, and Occupations)
- O*NET (Occupational Information Network) frameworks
- Strategic Intelligence platform, World Economic Forum

Theoretical Background

The current static models of Skills & Competencies cannot explain how the technological changes of Industry 4.0 cause skills mismatches and do not allow suggesting innovative learning options. Until now, the training of teachers had a substantial prevalence of "silo-ism" thinking, specialization, and differentiation of disciplines. As a result, teachers are not currently qualified to prepare students to develop the required skills for jobs that do not yet exist and adapt to working conditions not even foreseen. The acquisition of future skills for higher education students is related to interdisciplinarity. Jacobs indicates that silo-ism is a barrier to the interdisciplinarity of academic disciplines [14]. He mentioned that the domains are "silos", such as remote, lonely, and quiet places with high walls, designed for insulation and to protect their content from the external environment. With this analogy, he means that disciplines are focused, tend to block the attention to other fields, and the intellectual focus is directed toward the center of the area, leaving away marginal topics.

Moreover, the issues were in a hierarchy or priority. These characteristics bring disadvantages to communication inhibition, stifling innovation, and providing a fragmented education to undergraduates [17]. Another critical aspect of getting those future undergraduate students to achieve these future skills is the teacher. The teacher's importance as a human resource is well known for reaching educational objectives [18]. Moreover, a shortage of pedagogy of faculty professors in technology-driven Education has been declared in some studies, which do essentially analyze teacher qualification [19]. However, scarce studies have been performed evaluating the necessary competencies of teachers for the Industry 4.0 challenge. From the perspective of educational policymakers, a research survey identified the main competencies that vocational schoolteachers in Indonesia require in Industry 4.0. The pedagogical competencies were considered extremely needed, such as the ability to develop students' potential, understand students in-depth, and understand the characteristics of students from diverse aspects. Social competence is the ability to communicate orally and in writing. Advising students with psychological problems, according to personality, professional skills, standards, and work ethic, appears as one of the primary professional skills [20]. Finally, an interview with personnel at an Ecuador University shows the balance between soft, technological, and critical thinking skills in teachers for Education 4.0 [19], [21]. The "Future of Manufacturing" report mentioned that Industry 4.0 would be converged, connected, and collaborative in the next ten years "*driven primarily by pressures on businesses to achieve the outcomes of improved productivity, production output, profitability/costs, competitivity, and sustainability and the circular design."* In this sense, new roles and engineering degrees should be interdisciplinary and multidisciplinary. Skills related to new technologies, digitalization, and soft skills are essential. Engineering has been stereotyped as weak in soft skills (interpersonal skills, communication), so there should be a change in the tunnel mind of *"what I do"* to understanding what others do and how they relate.

Therefore, everyone must understand and participate in how things and technology are evolving in the upcoming workforce. Work in teams and engage with colleagues in the transition. Still should be resolved challenges among academia, industry, government, and accreditation bodies. For example, there are ideas that industry and academia are far away and disconnected when both spaces allow for new developments and should give credit. The industry needs the integration of topics and skills to adapt from the academy, and academy updates in the curriculum and things that cannot cover need an industry partner. Government must create policies on how to fund Education and opportunities to implement changes in terms of skills. Also, the accreditation body requires the ability to communicate effectively. Innovation, soft skills, and engagement come from diversity, which must be embraced for solutions with more impact. Even when the workforce or students in academia possess all skills, if they do not feel included, problems may occur. Then, strategies for STEM engagement that consider underrepresented groups with social-economic backgrounds or different identities are essential. There is a need for talent and skills in manufacturing spaces. International reports by the World Economic Forum and the Organization for Economic Cooperation and Development suggest that this situation will affect resolving urgent societal needs due to the unknown impact of skills mismatch and lead to potential workforce talent shortages. Figure 1 shows the steps proposed by ASME to accelerate this transition [22].

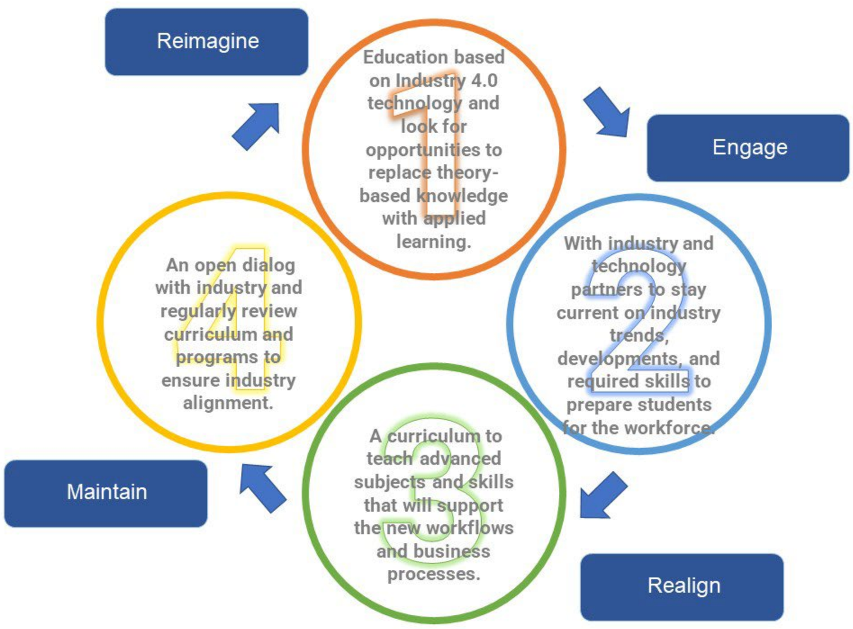

Figure 1. Steps for academic evolution to prepare for the challenges of Industry 4.0 (figure based on ASME webpage [22]).

The industry's requirements evolve faster every time, expanding beyond the scope of the existing education and training programs. Thus, the skills frameworks for every student generation are dynamic. Furthermore, as indicated by the arrows in Figure 1, every transition to a new industry framework involves a cycle for academia to prepare the next workforce. However, despite the urgency to make the training of Gen Z students in *Futures Skills* more flexible, nowadays, there are two latent challenges to face the disruptive changes of Industry 4.0:

- Most of the curricular programs of Higher Education Institutions continue to have a strong predominance of "silo-ism" thinking, with a rigid degree of specialization and a marked differentiation of disciplines.

- The current skills frameworks are static taxonomies that cannot explain how to make the necessary adjustments so that students are trained in the innovative and more efficient processes, products, and services required by Industry 4.0.

Thus, new models of skills taxonomies, and strategies for efficient communication among stakeholders (academia, industry, government, and accreditation bodies), are needed.

The international reports we consulted suggest that mismatches will arise between the current supply and demand for contemporary skills and between these skills and those required in the future. Closing these gaps will need a solid understanding of the existing skills bases in particular countries and industries and how disruptive change will dictate new skills requirements in each case. Therefore, consistent with the findings of international reports, we raised the following research questions:
RQ1: *What kind of Skills & Jobs model would Higher Education Institutions need to prepare students for a life of continuous challenges?*
RQ2: *What are the most appropriate artificial intelligence tools for implementing a dynamic model that is accessible and can be consulted worldwide by teachers and researchers?*

Methodology

The methodology consists of three groups of activities to achieve the project goals:
Construction of the Taxonomy and Framework. Using the PRISMA methodology, a systematic review is being made to build a taxonomy and framework of the skills and competencies required by Industry 4.0 employers. The various aspects that will make it possible to operationalize the tools of a model are being analyzed to adopt a common language for skills and identify skills-based strategies universities must offer to link Industry 4.0. The taxonomy will have a matrix approach that combines skills and occupations as a base, initially, the reports of ESCO (European Skills, Competences, and Occupations) reports and the Occupational Information Network (O*NET) framework to continuously feed the dynamic taxonomy. It will be necessary to develop a platform that is also dynamic and whose database will describe the characteristics, skills, and knowledge requirements of the occupations. Additionally, considering the curricular programs of the universities in the Top#100 of the QS University ranking will obtain a relationship between programs, careers, and competencies.

Construction of the Dynamic Model with Machine Learning tools. Once information is obtained from the different reports, frameworks, and the taxonomy is created, the system must be on the lookout for new skills that are arising. While this could be constructed with a team that continuously reviews the literature and modifies the information, having tools to review the information and update the skills according to the model is helpful. Thus, we will use topic modeling tools such as Latent Dirichlet Allocation to generate the most common topics from the information being generated and see if there are changes in the prevalence of specific skills. Then, as new needed skills start gaining notoriety, the dynamic model will take note of them and add them so they can be studied.

Creation of a community of collaborators on GitHub. The global framework, dynamic model, and assessment indicators will be available for teachers and researchers in an open-source artificial intelligence and deep learning program. Higher Education Institutions can obtain updated information to modify, adapt and improve their educational frameworks or the configuration of any active and experiential Learning based curricular programs. A global community of educators and educational technology innovators will be able to participate in tracking and contributing to the ongoing development of the model through collaborations on GitHub. Universities will be invited to register their teachers and researchers to collaborate and test the Dynamic Model functionalities. It will include personalized inter-consultancy to design active and experiential learning approaches and updated information on Market Strategies related to Education & Skills 2030. We will work collaboratively with partners (universities, companies, accrediting associations, and industry) to track and contribute to the ongoing development of the model through changelogs and suggestions via GitHub.

Workplan and Discussion

Figure 2 schematically shows the project's 2023 work plan. The left section of the figure offers an overview of the tasks implemented between January and June 2023. The right section shows an overview of the steps from July-December 2023.

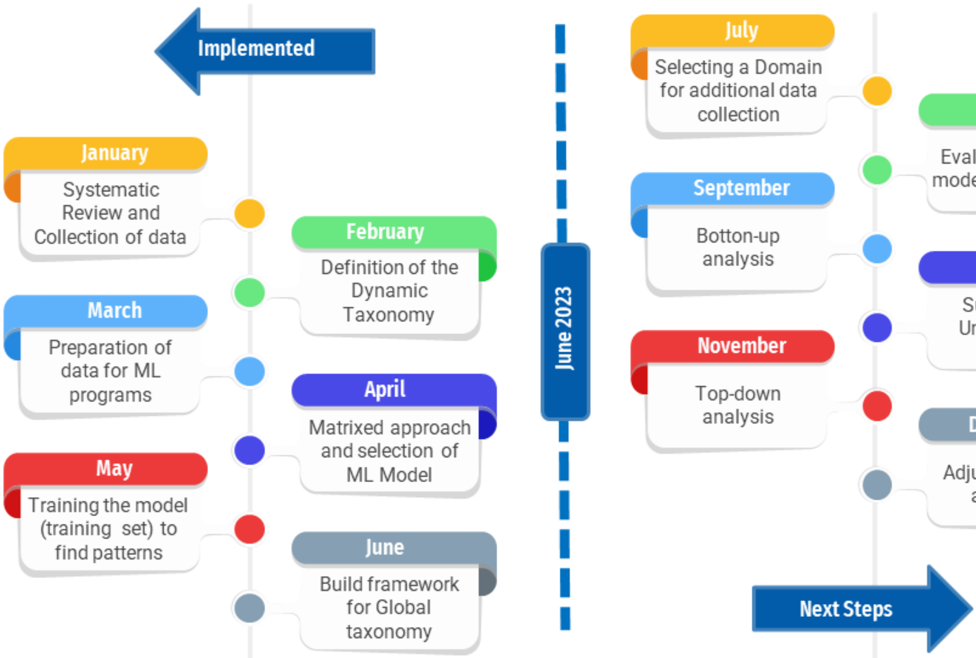

Figure 2. Timeline of the project: implemented by June 2023 and Future work.

Activities already implemented. The experimental setup was done through the dynamic platform, selecting a specific domain and applying a dynamic taxonomy to obtain data from the selected sources. Then, the data were analyzed, and statistical validity tests were carried out through the same platform, which served as the basis for constructing the model. The first step was to conduct a literature review analysis to operationalize the model's tools for adopting a common language for skills and identifying skills-based strategies in universities and industries. Following, the definition of a dynamic taxonomy of skills and competencies by industry 4.0 employers was made. Next, the clusters of skills and competencies were categorized to obtain groupings by levels of granularity and allow the expected functionality. During that period, we continuously fed the dynamic taxonomy with the reports by ESCO (European Skills, Competences, and Occupations) and the Occupational Information Network (O*NET) framework. The taxonomy has a matrixed approach that combines skills and occupations. In addition, the database describes the occupations' characteristics, skills, and knowledge requirements. For example, the curricular programs of the universities in the

Top#100 of the QS University ranking fed the data matrix to obtain a relationship between programs, occupations, and skills.

Next steps for the last months of 2023. First, tools and algorithms based on machine learning will be programmed to create a flexible document, updatable and with machine learning capabilities, to offer a prospective of the labor market, the trends and recommendations of employers, accrediting associations, and updated requirements from Industry 4.0. Second, a 'bottom-up' analysis using Machine learning procedures will be carried out to analyze the data of the educational organizations of the *training set* (<200 range of the QS Ranking). Third, the identification of natural patterns in the data using 'supervised/unsupervised learning' will be carried out to explore new clustering and segmentation approaches not biased by established and traditional education taxonomies. (The information of universities with 201<QS< 600 as a *testing set*). A 'top-down' analysis will be carried out using Machine learning procedures created from the data collected and fed by the global network of higher education experts. This analysis will incorporate considerations of the model's context, history, purpose, business model, technologies, and university ecosystem relationships to add depth and interpretive understanding to the process. Finally, validate (using Artificial Intelligence and Machine Learning tools) the principles for implementing the taxonomy and framework to align the supply and demand of learning for skills and competencies with a program of 3 modalities: competency training, upskilling, and reskilling. For the model, the data from the domains will be extracted, and the topics modeled manually, as with the current reports, a team of experts can deduct the skills reported and required in this time frame. Then, the model will be trained to obtain the skills according to the dynamic taxonomy, and the two results will be compared. As the documents that contain information from the skills can be clustered regarding the skills and topics obtained, the validity and reliability of the model can be measured using cluster validity indexes that review how different clusters regard one another. The comparison will calculate the difference between the human and machine-generated clusters.

Figure 3 schematically shows the project's 2024 work plan. The activities of the last six months of the project will be aimed at disseminating the knowledge acquired and making the platform known. To do this, it will begin in January with a series of webinars with international partners. Next, special workshops will be offered at an international conference on Education. Finally, the international Validation will be carried out through Functionality Tests and validity verification of the framework, both with international partners -university and commercial-.
At the same time, the design of the user manual will be finished, and the final documentation with conclusions will be ensured. Finally, all the documentation will be presented at an International Symposium on Skills and Jobs.

Conclusion

Preliminary findings show that the dynamic model can serve as an international reference guide for designing the 2030 educational approaches of active and experiential learning in Higher Education Institutions. The Global Taxonomy will address the requirements of international standards, accreditation organizations, and the needs of industry, business, and society stakeholders. Additionally, the implemented model will allow Higher Education Institutions to design pedagogical strategies, innovative learning options, and decision-making for developing future skills in disciplinary programs with a worldwide perspective.

The platform also will help prepare students to deal with different levels of skill mismatch or even skill obsolescence in their professional lives.

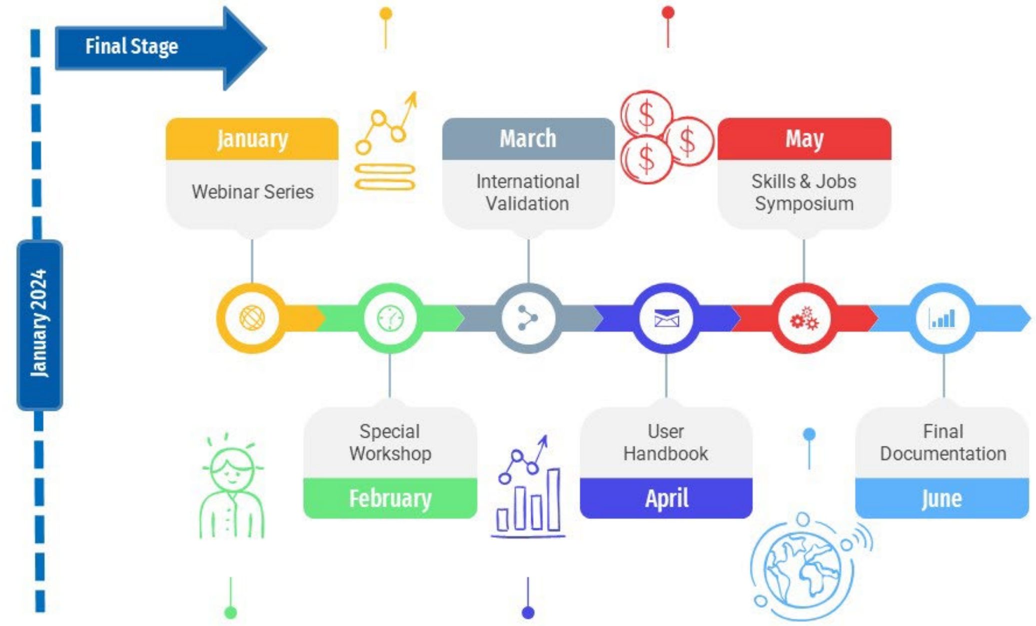

Figure 3. The expected final stage for 2024.

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