International Journal of Advanced Engineering Research and Science (IJAERS)
Peer-Reviewed Journal
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-9, Issue-2; Feb, 2022
Journal Home Page Available: https://ijaers.com/
Article DOI: https://dx.doi.org/10.22161/ijaers.92.36

Environmental Engineer Profile: Active Learning in Engineering Education

Priscilla Chantal Duarte Silva[1], Ricardo Luiz Perez Teixeira[2]

[1]Instituto de Ciências Puras e Aplicadas, Universidade Federal de Itajubá, Brazil
Email: priscillachantal@unifei.edu.br
[2]Instituto de Engenharias Integradas, Universidade Federal de Itajubá, Brazil
Email : ricardo.luiz@unifei.edu.br

Received: 29 Dec 2021,

Received in revised form: 08 Feb 2022,

Accepted: 16 Feb 2022,

Available online: 28 Feb 2022

***Keywords*— active methodologies, engineering education, engineering teaching.**

***Abstract*— Several discussions have been raised in higher education institutions for the formation of the environmental engineering graduate profile to fulfill the innovations of Industry 4.0 and the tripod of sustainability, required by the labor market. The agencies responsible for the management of engineering courses have established a series of changes in the teaching plans of the curricula of engineering courses in Brazil so that universities can attend the contemporary trends in the global market. The aim of this study is to identify the profile of the egress of the environmental engineering course at a public Brazilian university, verifying the impressions and demands of this public about their professional training; investigating the demands and the constitution of the professional profile determined by companies, in order to compare what the educational institution is dealing with in the curricular parameters versus what the market is demanding; raising the demands of the boards for engineering curricula updates and, finally, verifying if the parameters determined as requirements of the engineering boards are being fulfilled by the university under study. The results indicate that the graduate profile not only brings evidence of how the university has been acting in the competencies and skills in engineering courses. It was also found that active methodologies have a significant role to perform in the teaching-learning of the new engineering education requirements. We conclude that the skills and competencies focused on economic, social, environmental, and humanistic issues complete the profile of the environmental engineering graduate in the modern times.*

I. INTRODUCTION

The importance of the many industry changes on the application and development of technological solutions in the face of industrial paradigms is evident over the last two hundred years of history. The fourth industrial revolution brought with it a focus on digitalization. The tools brought by digitalization have optimized the information exchange time in many production and service processes. This revolution also brought with it a greater autonomy in face of the new challenges for the survival of companies in an extremely competitive and global context, with its need for social and environmental responsibility, in compliance with the norms and regulations that these companies fit into. It is a set of technologies that allow the fusion of the physical, digital, and biological world [1]. The main technologies involved are additive manufacturing (3D); artificial intelligence (AI); the Internet of Things (IoT);

synthetic biology (SynBio); and cyber-physical systems (CPS) [1].

The changes caused by the implementation of Industry 4.0 also involve an education that addresses new methodologies for the stimulation of students for active learning (learning from practical experience, by trial and error in a methodical way) [2]. These methodologies enable students to solve problems and propose solutions based on the observation of the real world, interconnecting the university and labor market, reconciling, and creating a new autonomous style of learning.

This paradigm break occurs when the learner becomes responsible for his learning autonomously and efficiently, in response to the needs of the current issues of engineering and industry [3]. One of the active learning methodologies that can be employed is Problem or Project Based Learning – PBL, addressing themes covering environmental, economic, and social issues. The activity thus allows working with the fundamental elements of sustainability, as brought by the triple bottom line and Industry 4.0.

The United Nations - UN and its partners in Brazil have set 17 goals and targets for sustainable development: poverty eradication; hunger eradication; health and well-being; quality education; gender equality; clean water and sanitation; clean and affordable energy; decent work and economic growth; industry; innovation and infrastructure; reduction of inequalities; sustainable cities and communities; responsible consumption and production; decisive action against global climate change; preservation of life on water and life on land; peace, justice, and effective institutions; development of partnerships and the means of implementation of sustainable development programs[4, 5]. These goals and targets aim to stimulate in the coming years a better and sustainable world for all. All these sustainable development goals are determined by the UN.

Higher education plays a key role in the transition to the fourth industrial revolution (4RI) [3]. However, current higher education programs still carry a model based on meeting the needs of previous industrial revolutions, whose demands were also different in terms of demographics, health, literacy levels, social inequality, and climate change.

The changes made in higher education to conform to the 4RI have been discussed by the institutes and their education bodies for their implementation in the various curricular structures, with an emphasis on engineering.

The general concept of 4RI is based on the advance of the productive-industrial process and its relationship with the advanced technologies, such as 3D; AI; IOT; SynBio, and CPS [3]. The changes caused by the implementation of 4RI involve, besides the technologies involved, teaching, in general, with new pedagogical practices that encourage students to learn actively [2]. With the new technological changes of this revolution, as well as the demands for professionals who know how to deal with these technologies, universities are forced to update their curricula of undergraduate engineering courses to meet the demands of the labor market and establish the profile of the graduate student of each course, according to the demands of the modern times.

The integration between the problem proposed to the student and the practice found in the industry is a key point for Problem Based Learning (PBL) applied to engineering learning. The integration of PBL with industry problems also provides conditions for students to develop interpersonal and self-learning skills [2]. In this respect, the right educational approach to teaching and learning by PBL improves the ability of students to acquire and apply knowledge with problems from real-life situations.

The impacts of sustainability on 4RI are not yet fully known [5]. They are also a challenge in the organization of the labor market [6] and consequently for a new curricular structure of higher education, especially in engineering. Engineering undergraduate courses in Brazil are regulated by CNE/CES 11 resolution of March 11, 2002 [7]. The National Curriculum Guidelines for Undergraduate Education in Engineering - DCNs define the profile of the graduate they should create while considering a holistic and humanistic educational approach.

The national curricular guidelines for undergraduate engineering courses (DCNs for Engineering) have highlighted the importance of reformulating and updating the curriculum to meet future demands, that is, to prepare new engineers for the needs and demands of the market within the context of the 4RI and the competitiveness with the international market.

Therefore, the education of engineers must be rethought, not only in terms of disciplinary adaptations but also in its teaching practices. In this sense, there is, on one hand, a concern with training according to an effective curriculum and, on the other hand, a productive sector that "finds it difficult to recruit qualified workers to work in the engineering knowledge frontier" [7].

For this segment, the expectation demands more complete professionals, in the sense that they are better prepared for the reality of the market. Besides the technical knowledge of the area, the directives point to the need of working on skills and competencies in the formation of engineers, preparing them with other kinds of knowledge such as leadership; teamwork; planning; strategic management; and learning autonomously.

The graduate profile must be formatted in accordance with the professional profile required by companies, which includes technical and behavioral qualifications.

Competence is understood as the set of skills associated with knowing how to do, knowing how to act within a specific context, based on the knowledge obtained during the course. For example, all the knowledge needed for a specific profession, in the case of this study, the competencies focused on environmental engineering. Skills, on the other hand, refer to abilities learned through training, classes, experience, or observation.

However, it is not integrated into a context. For example, the learner may have the ability to use language to express his ideas in writing, but he may not necessarily have the competence to use this skill to draft a technical report in his area of expertise [8, 9].

Breaking paradigms, in terms of the use of active learning methodologies, helps the "teaching-learning process more positively and effectively, because they favor the participation of the student and contribute to his metacognition since it makes him reflect on his own way of learning" [10].

However, to achieve this goal it is "necessary to readjust the engineering curricula and their pedagogical course plans (PPCs), as well as a better receptivity of both teachers and students" to the new learning technologies.

The objective of this study is to evaluate the graduate profile of the environmental engineering course at a public Brazilian university, using the survey method, through the collection and categorical analysis of the graduates' opinions and reports about the labor market in this field and in the course, as well as to investigate whether the parameters of the requirements of the engineering councils are being met by the university under study.

II. INDUSTRY 4.0 REQUIREMENTS

It is known that, currently, because of technological advances, the search for more complex, efficient, and high-quality products, the industry, known as 4RI, has directed the market. It has forced the university institutions to promote structural changes that meet this scenario of the industrial world, in which innovative technology is associated with the secure use of the Internet in the transit of digital information [11].

This need for a change in paradigms is also noticeable by the students in this research, who observe, upon finishing university, huge differences between what the school has taught them and what the market demands from them. 4RI brings a new paradigm that promises to redefine the map of industries' production systems [11].

The need to invest in human capital is well known for several reasons [3]. One is concerning higher education in responding to the demands of the automation and 4RI economy.

Although 4RI is intended to generate inclusive benefits with new jobs in the market, there is also concern about the emergence of some negative externalities and socioeconomic problems such as the extinction of traditional labor [12].

The impacts in social terms are related to the replacement of the workforce by machines, making less-skilled jobs scarcer in the future and increasing the number of unemployed, depending on the level of economic development or the speed of transfer of jobs from the industrial to the services sector in each country. In economic terms, 4RI can generate major impacts on several macroeconomic variables, such as gross domestic product (GDP), investment, employment, consumption, and inflation.

The improvement of skills and abilities are demands from the labor market, as 4RI imposes on industries and their professionals a better qualification. In this way, one can preserve jobs, adapt to recent technologies and organizational changes. Consequently, there is intense pressure for greater access to higher and quality education [11].

The three main competencies based on the challenges imposed by the fourth revolution are (i) the functional, understood as those to meet the technical and professional needs for task performance; (ii) the behavioral, skills intrinsic to the individual himself and (iii) social, the ability of individuals to relate in a group.

The big challenge, therefore, is how to extend learning and innovation into the workplace. Competencies and skills, in this context, need to be coupled with educational redesign to aggregate public, private, and scientific interests in response to 4RI.

The challenges of 4RI sustainability are related to economic, social, and environmental aspects, and not only to the profit of the production activity [4, 11]. An environmental sustainability model must, at a minimum, involve the rational allocation of natural resources, the minimization of waste, or the proper treatment and disposal of such waste. In other terms, the rate of exploitation of natural resources should not exceed the rate of regeneration, just as the rate of waste generation should not exceed the absorption capacity of the biosphere and the depletion of non-renewable resources [13].

On the other hand, while the current scenario is full of complex global environmental challenges, 4RI arises from the union between the availability of technological digital innovation and consumer demand for high-quality and differentiated products. Even though the 4RI principle is not focused on providing solutions to the ecological problems faced by production, but on increasing productivity, revenue growth and competitiveness have also dealt with the need to produce within environmental constraints geared towards sustainability, considering a reasonable environmental budget, which must be within the demands of contemporary society [5].

However, it is important to investigate how 4RI affects

environmental sustainability, as despite its potential benefits, these may be limited by technological infrastructure [14]. Digital technologies are also experiencing global environmental pressure related to the growing trend in energy demand and the urgency of adopting low-carbon energy systems [15, 16].

Moreover, although not unanimous, some academic studies have shown that producing in an environmentally initiative-taking manner is not synonymous with higher expenses, as there are also benefits and competitive advantages related to early environmental activities [16, 17, 18].

The implementation of 4RI impacts the Triple Bottom Line (3BL or TBL). 3BL states that organizations must go beyond economic results, not just focus on direct profits. From this vision, the results must be thought of by three main factors: social, environmental, and economic.

The first factor encompasses the satisfaction and quality of life of the people who are directly or indirectly linked to the company, such as employees and stakeholders.

The second factor concerns environmentally responsible and sustainable actions, such as the use of renewable energy or the appropriate use and recycling of materials, in sum, words, the transformation of passives into environmental actives.

The third factor refers to the goal of profitability combined with improved quality of life for people, through environmentally friendly practices.

It can be said that 3BL also promotes responsible and sustainable manufacturing; environmental responsibility; energy and resource conservation; renewable and less polluting energy consumption; recycling; minimization of packaging and carbon emission reduction; and the development of social responsibility in products and services [19].

In this approach, these three factors must interact comprehensively with each other. When this is done successfully, the company can be categorized as sustainable. Sustainability is one of the pillars of the competencies required to train environmental engineers.

Due to the high consumption of electric energy and natural resources, as well as the need for cleaner sources of energy and the creation of more efficient technologies that can minimize environmental impacts, engineering professionals need to have not only the experience in a specific area but also broader expertise, so that they can relate their particular knowledge to other surrounding areas to understand and integrate production processes.

To this end, a methodological change in engineering education is crucial for professional development. The traditional methodology has proven inefficient when applied en masse. In this way, PBL can be a learning strategy for students to apply their knowledge to realistic and complex models.

Besides this, there is also the development of the ability to generalize and to learn different systems and tools that are relevant for engineering programs, because the professional of this area will need to propose solutions to problems that are often multidisciplinary [20].

In terms of 4RI with 3BL, the aim is to work on engineering within a sustainable approach to manufacturing while using the PBL methodology to improve production efficiency, merging profitability with environmental and social responsibility. Sustainable manufacturing seeks to implement processes and products that benefit society, do not damage the environment, and are economically viable.

By stating that sustainability, proposed as a management practice, this line of thought raises the efficiency of resource use and has better logistical interaction and efficiency, both socially and environmentally, when compared to more traditional approaches [21, 22].

III. THE USE OF PROBLEM BASED LEARNING IN ACTIVE TEACHING METHODOLOGIES

The basic principle of Problem Based Learning (PBL) is a focus on problem-solving. PBL was established as a method of working with real, everyday problems for teaching purposes. This methodology is based on the hypothesis that by bringing cases from the students' extracurricular reality; they will be able to learn more easily. PBL was originally formulated to address the problem that many students were unable to apply content learned in the classroom to real-life problems [23].

Real-life problems motivate the students to study the required content knowledge to solve them [21]. The methodology emerged in the medical school in the 1970s, at Michigan State University, with the intention of articulating theory and practice based on real cases.

In this way, a case was problematized and taken to the classroom, contextualizing the theoretical content with cases from reality, which the students would encounter in their professional lives. Such problems instigate consequent studies in monographs and scientific initiation research by the students [20, 24, 25].

Another relevant aspect of PBL is the positive impact on increasing self-confidence in students [26]. There was also another benefit from this approach, as "it contributes to metacognition, since it makes them reflect on their own way of learning".

By using PBL, from the exploration of a problem, to solve it, the student recognizes his best way to learn, as he will try to find the solution to the proposed problem by himself.

In this case, the teacher will function as the facilitator of learning, guiding him in the discovery process. Thus, the student will perceive his learning mechanism, in a form of metacognition [2].

From this curricular change, PBL gained space among other domains of knowledge and in other courses, contextualizing education with real-life problems. Therefore, PBL motivates the students to achieve independent learning [27]. This strategy to problem-based learning has been increasingly expanding in higher education fields other than medicine [27].

PBL contains many different approaches, but usually, it focuses on the instructional nature of case studies and project development [28]. In this way, the students learn by observing and solving problems from real situations and they become more active in the learning process because they are responsible for their learning. In this sense, the teacher becomes only a facilitator, while the students formulate and analyze the problem by identifying the relevant factors of the educational scenario.

PBL is characterized as an effective teaching methodology for developing skills in collaboration, communication, interdisciplinarity, innovation, and social responsibility [29].

In this sense, it is a methodology that has the purpose of innovating while fostering the development of the cognitive maturity of the students.

There is in PBL a strategic opportunity to provide more active teaching, in what they call a "real world of learning opportunities," so that learners can work with real sustainability cases [30].

Thus, the application of active methodologies in higher education has become an opportunity to renew the curricula of the universities, bringing students closer to the reality of the market.

This methodology, therefore, becomes a positive teaching strategy for the cognitive stimulation and motivation of students. Moreover, it is one of the requirements of the new DCNs. In the case of engineering courses, these methodologies help in the training of students for the new directions of the 4RI and 3BL.

IV. METHODOLOGY

The methodological basis of this study is based on mixed research, using the survey method with the questionnaire technique. To investigate the profile of the former student, we used the guidelines on competencies and skills, provided in the new national curricular guidelines for all undergraduate engineering courses, according to CNE/CES n.2 April 24, 2019 [7].

Once the competencies and abilities foreseen in [7] had been surveyed, a questionnaire with open and closed questions was prepared and made available on Google Forms for all students graduating from the environmental engineering course at a public Brazilian university selected for this study.

The sample space was 120 former students, considering the range of years from 2015 to 2020. The study of the former students covered from the first graduating class of the environmental engineering course of the selected university until the end of 2020.

From the universe of 120 graduates, we obtained n=36. Thus, we worked with a percentage of 30% of respondents/informants. In effect, the margin of error was 11.55%, according to the sample calculation by Solvis Company - research solutions; a 90% confidence level with heterogeneous distribution. The margin of error is the variation index of the results of a survey.

As the research was also dimensioned with a qualitative nature, the open questions of the questionnaire were analyzed and categorized for a better understanding of the results.

The categories were delimited considering: the respondents' opinion about the market demands; technical training; computer skills; languages and communication; personal relationships; technical writing; management;

qualification and knowledge of the technical area. In a second moment, a search was conducted in the best-known job vacancy websites in the country, such as Vagas.com, Catho, LinkedIn, Vagas Online, Jooble, Temos Vagas Online, and Seleção Engenharia, to verify the demands of the job market in the environmental engineering field.

The search keywords were environmental engineer, environmental engineering, environmental, environment so that it was possible to include job announcements that covered the whole area of environmental engineering or required this type of professional training.

We selected thirty-five job advertisements from dissimilar sources and companies to analyze the professional profile required by them, as well as the skills and competencies involved.

The selection was random considering the entire national territory. The exclusion criteria adopted were internships; trainee; and ads without profile, since the focus of the research was to investigate the profile required of the professional who had already graduated.

Ads without a profile, i.e., those that only inform the requirements regarding education and professional experience, without specifying details about the desired profile, such as the expected characteristics, skills, and competencies, were considered. From there, we observed what was common to all statements in the ads and computed the data, according to Table 8. We also observed in the statements the description of the job vacancy, and the respective prerequisites listed in them.

We also categorized the requirements found in the ads, considering technical requirements linked to the knowledge or the knowledge needed to perform the job; the desirable skills or what the company determines as a competitive differential trait for the candidate, in addition to characteristics and qualities determined by the companies, such as those linked to human and personal behavior.

Thus, a cross-referencing of the data from the survey with the former students, based on the questionnaire applied, with the data obtained through the selected advertisements, was performed.

It was assumed that the perception of the graduating students would reflect the reality of what companies demand from them when they get to the job market. In the same way, job vacancy announcements often contain a description of the profile requested. In this respect, it is worth remembering that the graduate profile refers to the estimate of how the student has reached the job market after finishing the undergraduate course, considering the parameters established by the competent Brazilian bodies. The professional profile demanded by companies, on the other hand, reveals what must be adapted in the curriculum while meeting the university learning requirements.

V. RESULTS AND DISCUSSION

Based on the principle that the professional profile required by the companies serve as an orientation for possible curricular changes, and that the graduate profile reveals the need for changes and adjustments aimed at meeting the market demand, it was possible to observe that the professional profile focuses on a summary of qualifications; skills; competencies; and the need of previous experiences.

In this way, we tried to observe in the wording of the ads the skills that are consistent with the environmental engineer's profession.

Besides the informants' personal data, we tried to identify the following: the year of graduation; whether they are currently attending an undergraduate or graduate course; whether they are attending graduate courses, their graduate scenario to verify demands; whether they are currently working, and what positions they are holding.

As for the graduate scenario, presented in Figure 1, it can be observed that: 41.6% are pursuing graduate studies; 8.33% are pursuing another undergraduate degree; 50% are not pursuing another degree; 16.7% are pursuing graduate studies in the area; 13.9% have already pursued some graduate studies in the area; 38.9% are not pursuing any graduate studies, but intend to do so; and 30.6% do not intend to pursue graduate studies. This indicates that most of the informants are interested in pursuing studies in environmental engineering.

Fig. 1: - Post-graduation scenario

Source: author's data

Table.1: Post-graduation scenario

Post-lato sensu in the environmental area	Post-lato sensu in other areas	
Post-graduation in Water, Environmental and Energy Resources	Postgraduate in Finance, Investments and Banking	Master in Remote Sensing
Specialization in Geoprocessing		
	Postgraduate Diploma in Occupational Safety Engineering	Master in Energy and Environmental Engineering
Specialization in Urban and Environmental Engineering		Master’s in water resources management and Regulation
Environmental Management		
Environmental Management, Licensing and Auditing		Master’s in environmental management and Geographic Information Systems
Specialization in Water and Environmental Resources		Master’s in water resources management and Regulation

Source: author’s data

The search for a graduate degree in the area reveals the graduates' behavior as to their interest in continued education and their expectation of staying in the area, which reveals a future estimate. Adding those who have already taken courses with those who intend to, and those who are taking courses, we got a satisfactory result, as far as interest in continuing the study is concerned.

Table 1 below shows the areas of greatest interest to graduates of the environmental engineering course. For both the *lato sensu* and *stricto sensu* courses, one notices a preference for the thematic areas of the environmental engineering course or areas related to the profession.

In this case, the scenario indicates which are the most sought-after areas, which may lead one to believe that they are more promising areas in the students' view or areas that are more desired by them. Moreover, this indication can also guide the course in the choice of certain areas.

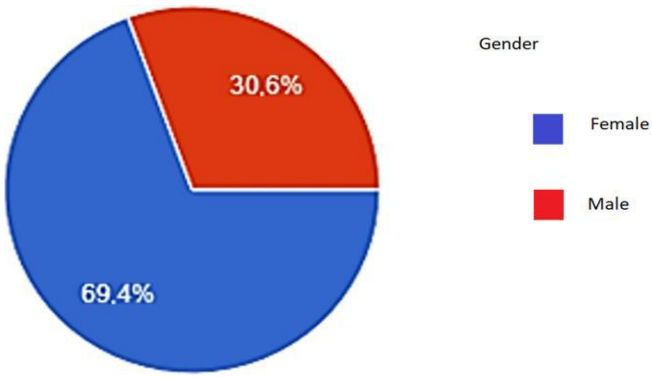

Fig. 2. Gender variable of informants

Source: author’s data

Table.2: Are you currently working in the area?

Sim		In another area	No
In the area	Freelance/consulting		
23	5	2	11

Source: author’s data

As for the gender variable, illustrated by Figure 2, the public is more female, both in terms of the number of respondents and the total number of graduates, which indicates greater participation of the female public in the course studied.

Table 2 illustrates that: 63.88% work in the area; 5.55% work in another area; 30.55% do not currently work, which indicates that most graduates already work in the area.

Table.3: Positions held by informants

Positions in the area	Positions in the area
Full socio-environmental specialist	Global buyer of specialty ingredients
Hydraulic Engineer	Data Analyst
Environmental Analyst	
Town Hall Technical Officer	
Environmental Technician	
Environmental Supervisor	
Jr and Plenary Environmental Analyst	
Quality Manager at ISO/IEC 17025	
Project analyst	
Environmental Technician	
Technical Consultant	
Geoprocessing Analyst	
Environmental Supervisor	
Environmental Analyst	

Source: author's data

Table 3 shows that the positions held vary from engineer and analyst to technician. The result shows that most of the informants work in environmental engineering, which may indicate that these graduates are managing to work in the career, most of them already holding the position of engineer or analyst.

It is worth remembering that the names of the positions vary according to the organization of the company and the specificity of the function, although all require a full undergraduate degree.

It was also asked, as shown in Figure 3, the level of satisfaction about the education and professional performance in environmental engineering. The name of the university was omitted for reasons of ethics and confidentiality. The graduates indicated that, in general, they are satisfied with the education offered by the university. It is believed that most of the informants have a positive perception about the environmental engineering course at the university where they graduated. Satisfaction is related to the state of Flow. The subject in this state is spontaneously and productively engaged in an activity [31]. When the subject reaches the Flow state, he is fully satisfied with the activity performed. He has more creativity, autonomous thinking, and well-being.

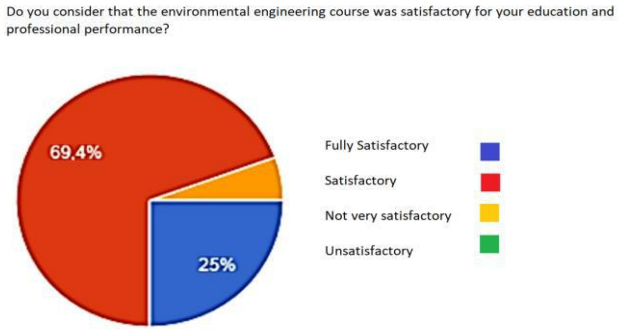

Fig. 3. Satisfaction about the training

Source: author's data

As for the market requirements, as exemplified in Figure 4, some categorizations were organized as follows: technical education, i.e., requirements as to an undergraduate and graduate degree; information technology: AutoCad, ArGis, Excel, and advanced Office package were the most listed. The same software also appears as a requirement to complete the profile of the environmental engineer in the companies' advertisements.

It should be noted that the professional profile is the sum of technical and behavioral requirements. Under these aspects, several skills and competencies were found to be frequent in the advertisements. Most of them expose these skills and competencies in the description of the requirements for the position.

In principle, a certain regularity was observed in these ads pointing to the basic requirements: good behavior; flexibility; leadership; credibility; dedication; creativity; responsibility; motivation; ability to work in a team; concern for customer satisfaction; proactivity, and resilience. In addition, technical knowledge is also truly relevant and is added to these characteristics. It was also observed that graduates are required to have advanced computer skills. In the following job vacancy announcement (Figure 4), computer skills appear as a requirement and no longer as a differential. One notices that topographic software is also in high demand, given the need for precision in technical work involving calculations and graphical representation.

Environmental Analyst

Description / necessary requirements: - Education: Environmental Engineering - Proven experience in the function, mainly in environmental licensing - Knowledge in waste management, effluent treatment and topographic software (Google Earth and QGis) - Computer: Office Package (Advanced Excel, Word, PowerPoint and Outlook) - Be communicative, have an influencer profile for environmental education, good relationship with team and managers main activities: - Control and update environmental licenses with the regulatory environmental agencies - Ensure compliance with legal records, as well as compliance with the technical requirements contained in the licenses - Align environmental guidelines and policies through the implementation of standards corrective actions and improvements - Monitoring environmental performance, management results and indicators of the area - Ensure the implementation of monitoring plans (water, wastewater, waste, atmospheric emissions, fauna and flora) - Prepare projects and / or monitoring reports of ecological restoration - Develop environmental education programs with the community.

Fig. 4. Announcement Environmental Analyst

Source: author's data

Thus, the job vacancy announcements were analyzed together with the data presented in the survey to find out what were the common competencies and skills (See Table 4).

Table 4 shows that the university is not able to address this content within the pedagogical curriculum, following all the requirements described in the announcements. Thus, this knowledge can be contemplated throughout the course in complementary or extension activities. In languages and communication: advanced English and Spanish; experience abroad; oral and written communication skills were the requirements most mentioned by the informants. In personal relations, it can be said that personal marketing, soft skills, creativity, dynamism and proactivity, and teamwork complete the profile.

Table.4: Job market demands

Categorization	Market requirements
Technical Training	Undergraduate and Graduate
Informatic	AutoCad
	Argis
	Intermediate and advanced Excel
	Advanced Informatics

Source: author's data

Table.5: Market demands regarding languages and communication

Market requirements Categorization Languages and Communication	
Languages	Advanced English and Spanish
	Experience abroad
Communication	Written communication
	Oratory / oral expression

Oral communication / interpersonal relationships

Source: author's data

According to Table 5, regarding language knowledge requirements, it was observed that English is the most required language, followed by Spanish. Graduates are required to have these languages at an advanced or fluent level.

Oral communication was highlighted in the advertisements and the graduates' answers, both for interpersonal and commercial relations, and for training focused on environmental education. Therefore, this competence should be addressed in the environmental engineering course not only to meet the demands of the new curricular guidelines, but also to meet labor demands.

Table.6: Job market demands - technical writing and qualification

Categorization	Market requirements
Technical Writing	Reports
	Opinions
	Elaboration of projects
	Map-making and interpretation
Managemen t	Environmental Management
	Project Management
	Management in general
Hability	CNH

Source: author's data

In management, the opinion of the graduates emphasized knowledge and the development of skills in Environmental Management, Project Management and General Management. However, some advertisements also requested other forms of management for the specific area of environmental engineering, such as waste management. Concerning the qualification to drive vehicles, the CNH becomes an important differential. In the following advertisement, Figure 5, one can observe the importance of written and oral communication for the position of full sustainability analyst.

In technical writing, the informants highlighted the importance of having a proficiency in reports, opinions, project preparation, and map interpretation, as indicated in Table 6. In general, universities prioritize projects and reports, which are often used in practical activities in the disciplines. However, a more in-depth approach to reading, interpreting, and producing reports and opinions are necessary to complete the education of the students. Some announcements even reinforce the use of communication, both for their production processes and presentations.

Full Sustainability Analyst

1 position: São Paulo

If you want to work on our Vivo Sustainable program, one of the strategic pillars of our Digitalize to Bring Together purpose, this position could be your opportunity. We are looking for a curious, dynamic professional who enjoys challenges, and is committed to social and environmental issues, to join the Responsible Business team at the VP of Institutional Relations and Sustainability. The main objective of this employee will be to promote the circular and sustainable economy inside and outside the organization, developing and maintaining projects, working on process control, and engagement plans with strategic partners. Completed university education in Environmental Engineering, Environmental Management or related field needed. Experience with waste management: Experience in medium or large companies, consulting with various focal points; Knowledge of environmental legislation and proficiency in laws, resolutions, and technical standards on waste. Intermediate/advanced knowledge with Excel and PowerPoint; Communicative and analytical skills that enable the elaboration of technical reports up to managerial presentations. Experience with modeling and database, performing analysis and interpretation, deriving conclusions, recommending actions, and reporting results visually.

Fig. 5. Announcement Full Sustainability Analyst

Source: author's data

The technical knowledge highlighted were environmental legislation; environmental licensing; ISO14001; effluent treatment; geoprocessing; environmental analysis; data analysis; data science;

geotechnology; limnology; map-making and interpretation; experience with social relations; and environmental technical knowledge.

Table.7: The most relevant course knowledge

Knowledge	Knowledge
Remote Sensing	Elaboration of projects
Geoprocessing	Sizing of water and wastewater treatment plants
Resistance of materials	Statistics
Meteorology	Hydraulics
Geology	Renewable Energies
Management	Environmental Law
Environmental Management	Limnology
Environmental modeling	Hydrology
Administration and economics	Field classes
Ecology	Topography
Geomatics	Solid Waste
Recovery of degraded areas	Environmental diagnosis and technical analysis
EIS, PRAD and geoprocessing report elaboration.	Environmental Management
Basic sanitation	Oratory
Logic and Programming	Jr. Company
Teamwork	

Source: author's data

The most relevant knowledge and skills from the course that was described by the graduates revealed what has been important for the exercise of the profession (as shown in Table 7). In the words of a former student of the environmental engineering course: "I use a lot of content from the university. These contents complement each other for a complete understanding of the complexity of the interactions that occur in the various environments".

In these words, one notices the recognition that the knowledge worked throughout the course was useful for the professional life of the graduates. Although subjectivity is involved, it is noted by the answers of the informants that the knowledge pointed out as the most relevant in the course concerns impressions regarding the performance of the subjects, as well as the graduates' perception of the reality found in the labor market.

In this sense, it can be observed that not only specific knowledge of the course area is considered relevant, but there is also an emphasis on practical activities and transversal or interdisciplinary areas. It is believed that this is due to the skills and competencies recognized by the market at the time of hiring.

We can see that, in the graduates' view, there is a need to prioritize practice over theory, besides valuing the importance of extension practices, internships, and junior enterprises.

It is believed that this is a way of having contact with the reality of the job market and the basic contents of their course: "the greatest knowledge was gained through practical extension activities such as junior companies and internships" (former student of the environmental engineering course).

The importance of the knowledge of the legislation for the environmental engineering course is also highlighted. "Knowledge of norms, of laws, technical-environmental certifications, brought by environmental public agencies and a critical eye", is considered relevant, as shown in these words from a former student of environmental engineering course.

The results of our survey reveal that 80.6% of the informants believe that the course contents are satisfactory., while 13.9% consider it to be fully satisfactory, which indicates satisfaction regarding the basic content offered by the course. In this context, it is observed that there is neither dissatisfaction nor complete satisfaction with the course, but the students reported what could be further developed or improved in the course.

In Table 8, it is possible to see, from the analysis of the job ads, the requirements found for filling job vacancies by companies. For better organization, the ads were categorized into lists of technical knowledge, desirable or differentiated knowledge, and behavioral knowledge to better understand what the graduate needs to have to get the job.

Table 8 further shows the requirements for applying for environmental engineering job openings that align with the new profile of the professional former student, integrated with the fundamental elements brought by 4RI and 3BL. Some of the fundamental elements of 4RI are internet of things (IoT); cyber-physical systems (CPS); machine-to-machine (M2M) communication; cloud computing and BigData. These elements are present in the various programs required of the job candidate.

Table.8: Categorization requirements found in job ads

Technical Requirements Know-how / Knowledge	Desirable / Differential	Behavioral / Personal
Management of waste, projects, teams, quality, environmental	Language	Soft skills
Brazilian and International Regulatory Norms - NRs	CNH	
Circular economy and sustainability	topographic	
Environmental Legislation	Technical Information	
Environmental Impacts, Performance		
Environmental diagnostics and risks		
Occupational safety and environment		
Degraded areas and recovery		
Reports and technical reports		
Measurement and calibration equipment		
Management		
Geoprocessing		
Water Resources		
Solid Waste		
Atmospheric Emission		

Source: author's data

One of the principles of 4RI is to integrate the entire system horizontally and vertically to maintain data communication. Vertical integration acts on hierarchical levels, connecting all the company's internal processes, while horizontal integration refers to communication and data integration inside and outside the company.

In addition to making, it possible to work, share, and log data securely, these programs enable the user to work inside a data cloud. These principles are also aligned with 3BL by the integration they enable with each other, such as process security, resource efficiency, and the development of more flexible and intelligent processes.

In terms of 3BL, in Table 8, we notice greater demands in economic and environmental issues for the candidate for a job position in environmental engineering, either through knowledge and training in administration, which affect the productive systems of the companies or through experience and knowledge of management, norms and environmental legislation.

However, this focus has little direction on social issues such as work safety requirements; project management; and knowledge of the circular economy. It can be concluded that the profile of the candidate for the vacancy in environmental engineering is related to industry 4.0 and 3BL. However, little importance is given in the job ads to issues related to a concern for the community where the company is located. There is, therefore, a greater emphasis on the environmental and economic area in the advertisements.

It can be observed that besides technical knowledge, companies are looking for a professional who is willing to learn, initiative-taking, dynamic, and capable of bringing solutions to engineering problems. Once they have this knowledge, the chances of being hired will be greater.

Comparing the information collected in the advertisements with the pedagogical plan of the course, it was possible to observe that the course selected for this study addresses most of the market requirements. However, the expectations regarding management, computer resources, and specific management tools can be better explored by universities. Moreover, the inclusion of knowledge about soft skills is a challenge for the modern curriculum.

Although this knowledge is not treated in the curricular dimension, it can be worked on as complementary studies to the curriculum, or even, as an extension, according to the course organization and planning.

VI. CONCLUSION

The research on the graduate profile allowed the comparison of these profiles and professional competencies required by the labor market. It is concluded that the notions of sustainability brought by 4RI, environmental management, project management, waste management, and management in general, are crucial knowledge for training in environmental engineering and should be contained in the curriculum and in the pedagogical plans of the course.

The survey of the graduate profile can assist in decision-making by educational institutions to update undergraduate engineering courses, according to the guidelines of the competent educational bodies. Bringing together the demands of the market with the pedagogical content provides a more complete and up-to-date education. In this way, the student will have more opportunities in his or her area of activity. Although this study is for the identification of the graduate profile coming from the environmental engineering course, it also corresponds to a wide-ranging work, as it is also capable of involving the curricular updating of other engineering courses, in the most general aspects.

It is believed that this study can make use of the results to reformulate the pedagogical plans for engineering courses since many of the demands analyzed here are not only aimed at the specific area of environmental engineering. Furthermore, this is a study that involves current demands with a significant set of results.

In the decision-making process for filling job openings for environmental engineering, it was observed that, in addition to technical knowledge, there is also a demand for a professional with the following characteristics: willingness to learn; proactivity; dynamism; ability to point out solutions to engineering problems; ease of technical and personal communication in English, Spanish, and Portuguese. The students highlighted the importance of the link between the university and the industry to learn how to deal with the real problems of the industry. In this sense, the research points out that there is a need to implement PBL in engineering courses to meet the new curricular guidelines and ensure more effective teaching and learning.

According to the results of the satisfaction survey of the graduates, regarding their area of work, a search for continued education in a post-graduation course in the same field was noted, just as the importance of having a record of professional satisfaction among environmental engineers at the institution selected for this study.

The graduates are also satisfied with their education and current professional performance, having a positive perception of the environmental engineering course. However, they emphasize that the course is still very academic and that there is a greater need to make it more business oriented.

ACKNOWLEDGEMENTS

We would like to thank the Institute of Pure and Applied Sciences at UNIFEI, the Institute of Integrated Engineering at UNIFEI, the Faculty of Economic Sciences at UFMG, and the University of Lisbon for all their support in making this study possible.

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