

## Women in ICT Engineering Courses: Problem-Based Learning to Encourage their Empowerment

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**Abstract:** The disparity in numbers was evident and could not be ignored in terms of research: twelve students women, included in a class with a total of 126 students men, attended the last year of Computer and Multimedia Engineering Degree courses, at the Higher Institute of Advanced Technologies (ISTEC) in Lisbon, Portugal, in the academic year 2020/21.

The general objective of this study was to realize, through the different proposals of research themes, developed by all students in their practical project – the final dissertation (in order to achieve certification of their degrees) configured the reflection of what happens in society in general, referring to a gender set of stereotypes, which obstructs knowledge, stagnates or delays the ability to respond with new solutions for all, so common in these cutting-edge technological areas, and how to change the underlying mentality of women students and reconfigure positive impact on their action, mentality and on their technological practice in future proposals or jobs.

To better describe what happened, this research uses a case study that aims to demonstrate why Women in ICT are so few and how the use of Problem Based Learning (PBL) could help to understand why it happens. PBL was used to simplify research themes, based on real technological contexts and if those research themes made a difference from a gender point of view. Faced with so little female academic representation in this particular area, as a woman researcher, it was an imperative goal to recognize how and why this occurs so frequently, but also prove a simple theory: if PBL could be adapted for each person and maybe adjust in individual, social and professional terms, regardless of gender. Another challenge was to realize the biases and stereotypes perception and which these factors were reflected in the lack of gender equality and identity and promote incentives for women empowerment in the technological world.

**Keywords:** *Women in ICT, Identity and Gender Equality, Innovation, Entrepreneurship, Empowerment.*

### I. Introduction

The residual percentage of women (about ten per cent) who attended in 2020/2021 the curricular unit of Global Project (Methodology) – the third year of the Degree in Computers and Multimedia Engineering courses at the Higher Institute of Advanced Technologies (ISTEC) in Lisbon, clearly demonstrates the long road that still has to be covered for the much-desired gender identity and equality in this sector of activity.

The main goal of this study was to understand, that after so many years of the scholarly path with gender equity obstacles were overcome, particularly in this area of new technology. The doubt was to realize, through the different proposals of research themes, developed by all students in their practical project – the final dissertation (in order to achieve certification of their degrees) configured the reflection of what happens in society in general, referring to a gender set of stereotypes, which obstructs knowledge, stagnates or delays the ability to respond with new solutions for all, so common in these cutting-edge technological areas, and how to change the underlying mentality of women students and reconfigure positive impact on their action, mentality and on their technological practice in future proposals.

The specific objectives guided by Problem-based Learning (PBL) methodology, were simplified, outlined and made possible, unfolding research themes as well as prior questions, simplifying how students could organize their ideas to understand the main goals, as well as step-by-step execution of all Global Project chapters, that they must develop during research time. At the same time, another point emerged to understand whether the Pandemic's constraints, due to COVID-19, positively or negatively influenced in terms of creative freedom and decision-making. Maybe this strange time of successive restrictions

reflected the choice of more contained research themes, possibly decreasing the quality and questioning future portfolio availability to potential employers.

In order to describe this Case Study in detail, it was possible to analyse qualitative collected data. From October 2020 to May 2021, several observations were made both online and in-person classes, where were conducted informal interviews and personal reports appreciated. Most of the relevant data as described in the first person reveal students' expectations about their relationship with ICT and future projects. This practical scope occurs in a collaborative and editing tool named Padlet, where a considerable percentage of students (66) placed their tasks and their opinions, about methodologies options, professional beliefs and specific research areas, in order to complement the final grade of Global Project curricular unit.

In the end, it was possible to extrapolate some conclusions related to what the female students witnessed, when choosing the research theme: the prevalence of a very conservative, little visionary and quite repetitive use of ICT practices, as opposed to some of the 'radical' proposals presented by male students, who, without fear of daring, take challenges that were more difficult to reach. It was a research risk, to prove some theoretical purposes of this article, but as Stephen Hawking [6] wrote once in his book 'A Brief History of Time: From the Big Bang to Black Holes: "a theory is a good theory if it satisfies two requirements. It must accurately describe a large class of observations on the basis of a model that contains only a few arbitrary elements. And it must make definite predictions about the result of future observations" (Hawking, 1988, p. 10).

Does this mean that in the Women in the ICT case study here related, simple observation could be precise, reproducible and accomplish a predictive capability of mentality transformation? – Maybe the answer would not be possible in this article, however, it was the first seed thrown into the soil – and could be made a difference in future options of research.

## II. Literature Review

The percentage of just over ten per cent of female presence: 12 female students (in a total of 126 male

students) enrolled on the third year of the Global Project - Methodology curricular unit, attested the main limitations of this study expressed by an empirical theory: fewer women in this technological graduate courses, means lack of confidence and attractiveness of this area of knowledge or represent minor stimulus to captivate women (higher education institutions responsibility)? Why does similar behaviour happen in professional organizations worldwide? - Seems technologies it is a much more masculine universe and this is another relevant factor to consider.

The Organization for Economic Co-operation and Development – OECD (2018a, p. 5) [9] report describes that gender equality is much more than a fundamental human right, it is also "the keystone of a prosperous, modern economy that provides sustainable including growth". Besides, the same document materializes women's relations in Science, Technology, Engineering and Mathematics (STEM) areas and Information and Communication Technology (ICT) and the continuous promotion of school and university attendance in those fields [9]: "Girls and women are accumulating disadvantages and face increased barriers to their full participation in the digital world. Girls tend to participate less in disciplines that would allow them to perform well in a digital world (e.g. STEM and ICTs); use digital tools and participate in platforms to a lesser extent, also when it comes to advancing their businesses (in addition to receiving relatively less financing). This comes on top of the traditional obstacles and discrimination they face in the analogue world. Countries need to act promptly to intervene and redress this situation" (OECD, 2018a, p. 131).

Miliszewska and Moore [8] also reflected on the creation of an alternative to change the System: "The under-representation of females in ICT studies and careers results not only in a massive loss of talent for ICT companies and economies but also in a technology divide that perpetuates disadvantage among women in general and women of low socioeconomic status in particular. The already low number of female students studying ICT in secondary school tends to decrease further at the tertiary level. This situation has often been attributed to gender differences in interests, motivation, experience, personality characteristics, abilities, self-efficacy, and socialization" (Miliszewska & Moore, 2010, p.144).

So far there are insufficient visible results or data to evaluate because women's presence in this technological universe in constant mutation has been a bit controversial as follow authors reveal. Despite having completed ten years (in April 2021) on initiatives of global companies responsible for the urgency of the theme Girls in ICT, such as CISCO Systems, which seeks to determine why women are still under-represented in the areas of Programming and Software Development, Cybersecurity, Artificial Intelligence, Networks and in ICT in general. The fact is,

that little progress has been made, at the social and technological level since 2010. Miliszewska and Moore [8] pointed out some principles that could coordinate global action: “improving female participation in ICT studies and careers suggests three fundamental areas for attention: infrastructure, teacher training/attitudes, and the role of community” (p.163).

If the presence of women in technology, until 2020, had been noticed more in terms of social networks, YouTube and digital marketing, the apparent evolution obtained resulted in a regression, due to the COVID-19 pandemic. When international organizations such as International Telecommunication Union (ITU, 2021) express their concern and promote daily calls for women’s imperative participation. This challenge demonstrates the urgency of inclusive and equitable access and the widespread use of ICT for Girls/Women, developing global cooperation efforts and particular measures, suited to each country and region, in order to invest in digital skills, which need to be further developed from school, at an early age, to attending later on in higher education.

More specifically, Blau and Kahn [1] clarify that it is in education that lies the hope of equipping and training women and girls with the essential skills to participate and use digital media in order to validate, how women’s technological leadership must be normalized and treated as essential, and why discrimination does not make sense.

Other obstacles pointed out by women, who intend to be hired or who work in high-end technology companies, according to the study ‘I’d blush If I could. Closing gender divides in digital skills through education’ a report from EQUALS [3] (2019, p. 77) is the ‘ICT gender equality paradox’ which described that “countries with high levels of gender equality also have some of the largest STEM gender gaps in secondary and tertiary education”.

Moreover, that report [3] underlined a set of discriminatory acts that reveal themselves as gender-related. For example, the possibility of eminent women’s failure in technologies practice; the invisibility of colour and gender – as women’s opinion does not count ever; a kind of fundamental info-exclusion perceived by men, co-workers and higher hierarchical functions persons, who pretend to support minorities and defend quotas for hiring women and often uses stereotypes jokes and subliminal depreciation about some physical, psychological or social aspects.

However, the salary differences, the missing lifelong training, and fewer unavailable hours for the family reveal standing arguments. People with similar skills aimed to do the same techniques and work and receive the same money, but this does not ever happen which demonstrates once again the existing inequities. In EIGE [3] (2018, p. 46) this reality is reinforced: “The current unequal sharing of caring responsibilities, coupled with the need to keep up

with rapid technological advances, poses a risk of many women’s careers falling behind those of men”.

Problem Based Learning (PBL) is an old concept and for many years, it was mainly applied in Health, Engineering, Philosophy and Law teaching at Anglo-Saxon universities. According to Blumhof, Hall & Honeybone [2] (2001, p.6) in the article ‘Using problem-based learning to develop graduate skills: “PBL is an approach to learning and teaching that encourages the development and application of problem-working strategies and the acquisition of disciplinary knowledge bases and skills by placing students in the role of problem-workers”.

Teachers who use this learning tool (PBL) according to the authors Blumhof, Hall & Honeybone [2] can share activities, a fictional or real narrative, a game or a step-by-step guide, which allows the availability of information-sharing, data recognition and resource identification. Students using PBL could easily follow problem clues, questioning several distinct points of view.

### III. Performance and Methods

In the scope of this research, ICT and e-Learning classes coordinate main practices, due to COVID-19 and expanded a methodology based on PBL, already used for other interdisciplinary domains, but intended here, to promote basic principles of simulation and modelling, as well as inciting new thoughts, more inspiration and entrepreneurship for all the students of the two Computer Science and Multimedia Engineering degrees. Using PBL in this case study encourages the discovery of new perspectives, raising hypotheses as if it were a puzzle or a game, a proposes for those who are learning to think critically, and reflectively, formulate and test hypotheses and present potential conclusions, without fear of making mistakes.

The idea is to inspire assertive communication, without limits or controls, innovating and promoting different paths to achieve the same goal. The effectiveness of the process for digital media technologies in PBL, resulted in hybrid, mixed and applied different looks at the real world, such as Case Problem Learning, Gaming Problem Learning, and Storytelling Problem Learning, present in a collaborative tool named Padlet (a virtual board that enables written interactions and hosts all multimedia documents associated with a web presence).

This case study aimed to establish the relationship between the conditioning factors that keep women away

from attending higher education courses degree in Computer Science and Multimedia Engineering and try to explain why audacious and critically thought-out research themes development, focused on innovation, entrepreneurship, solutions easily convertible into business, as was widely seen on the male side of proposals submission, did not contemplate the 12 women's projects.

The group was 126 students that were enrolled in the Global Project - Methodology course unit, but only 66 Padlet responses were obtained for this case study.

There were several data collection instruments to consider: a Forum question was sent to everyone, through the Learning Management Content Systems Classroom - Google, available online. The activity was: to read and comment on a sentence, about how to solve problems and how people interpreted the challenges, that could arise in the meantime.

However, only seven women responded online, and the rest chose a more intimate place to do so: the Padlet – a kind of collaborative online activity notebook, which proposed a PBL continuous assessment of tasks, in narrative and mental maps format, making available a set of indications interpretation, that could guide into a potential solution, taking into account the specificities of each student.

Another issue was clarifying how they could more easily discover the best research themes suitable to their experience could be developed. Two examples were created based on PBL and the students were challenged to unfold the possible research object individual or in groups, so they could more easily find the research questions related.

In the first phase, as a Padlet task clarify, they drew a words cloud or a mental map about the problem to be solved, in order to understand if there was coherence or logic and if it really deserved their attention, for further research to be developed. Ideas were exchanged in online and offline classes, and even those students, who did not develop this exercise, were able to present their research problem and realize that information sharing could change everything because they got peers' feedback and more important new perspectives, which brought different eyes.

In the next step, through a Padlet task, they need to use a specific paragraphs creation methodology, based on lead questions (Who, What, Why, When, Which and How) to find out if the research problem was really viable, interesting and original. Afterwards, a simple orientation checklist was carried out: why this research theme could capture people's attention? What has already been done for its development? What are the results obtained and to be obtained? What benefits can you add? What differs from what has already been done, from existing solutions? Contributions, limitations and possible repercussions in a first analysis?

In addition, everyone must present their research

idea as a Pitch task in Padlet. The goal was evaluating, how they could sell an idea and listen to colleagues' and teacher reactions, check the degree of acceptance, regarding the potential theme, and guarantee the ethics and the veracity of the research path without plagiarism. When students took the first step, it was possible to adapt the ISTE Global Project Rules to the next stages of their research themes' progress.

## IV. Findings and Discussion

Remember that the first part of this case study theory wants to prove and understand the influence and the absence of gender identity and equality, as well as the fear of taking risks in terms of technologies and how those specific women students at ISTE, regardless of the degree they attended (Computer or Multimedia Engineering), expressed into original, innovative and enterprising themes in the development of their Global Project, with a potential future businesses perspectives or possible start-ups creation. Only 66 students of the Global Project (Methodology) course unit who took the Padlet assessments were challenged with practical initiatives, to find the best theme that suits them in a school and professional context. The proposed Padlet questions were intended to find out, how to create synergies to improve their learning in the computing, network and multimedia areas, fostering innovation, originality, entrepreneurship, collaborative work and leadership, without losing their gender identity, as people with different values, sensitivities and perceptions of the world. Although these themes were addressed to all 66 Padlet creators, regardless of gender, evaluated in this course, the most relevant suggestions, came from the female students and therefore inspired the writing of this article.

Regarding the originality of the proposals (Table1), there was a great cleavage between themes presented by women - moderate and no surprises, about something that would not give too much work or problems (more focused on the environment, on the relationship with women's beauty and health and animals, for learning, culture and entertainment) and those presented by men - bold and challenging, who intended to leave an innovation and a progress mark, challenging their own learning, because even if they didn't know how to execute: they would learn to do it, to carry out the project until the end, with the best quality possible, asking colleagues for help, without fear of sharing their lack of experience or knowledge about the subject.

**Table1: Type Of Gender Approach To The Research Theme Development.**

Women's research themes	Men's research themes
Environmental and ecological concerns. Websites and online stores.	Entrepreneurship and innovation, new approaches to networking, Cloud Computing, applications related to critical networks, Cybersecurity and Encryption.
Relevance to people and animals (health, well-being and beauty) preconfigured Websites and online stores similar to millions. Women in ICT Website as a way of the public sphere to discuss strengths and opportunities may be inspired by Padlet tasks.	Web applications and simulator apps to help land civil aircraft, networks development, digital environments 3D-360° and counters for games.
Commitment to learning and culture. eLearning platform (Laravel) and website for an online book and appointments repository.	Complex applications and Database (BD) to fill professional gaps, business potential apps, 360° virtual visits and augmented reality, 3D modelling environments, 2D and 3D games. Network applications were created to manage personal data in education and for the banking sector.
Universes of fantasy, fiction and entertainment: a 2D game (solitary path to understanding and reproducing a classic) and finally a short film theme research.	Online complex stores with websites, documentaries and a short (horror) film, mental illness 3D animation Videoclip: original music and design.

Another female student's concern was the insecurity of the unknown, when outlining some of the investigation paths traced, they were unable to adapt the soft skills acquired during the graduate learning attendance and cannot projected auto sufficient technical knowledge in their research themes. The idea of learning how to do it and looking on the Internet for someone, who knows better or asking for help from tutors or colleagues, with the possibility of imminent failure, in their opinions, could reaffirm the generalized conviction, that women are not good as technological experts as men. This sexist

presumption, often expressed and written by all 66 students despite gender, in their interventions and in the Padlet tasks, was one of the most common obstacles mentioned, barriers to more demanding topics presentation.

The differences in treatment between all students and some aspects of subliminal depreciation of female students exposed to technological contributions were also pointed out as communication barriers, that pledged teachers' and peers' relationships.

Women fear failure, negative words or indirect criticism in classes and try to justify their silence with the lack of knowledge about subjects (as the only woman among many men, she preferred to have no doubts). These women in ICT were afraid of making mistakes and gave up easily, not realizing that the real key to learning more, to having success is resilience, solving problems and dream always about something new.

Another stepstone was the anxiety and panic of some the women students, inherent to public demonstration of knowledge, either in terms of final written exams or in oral presentations (online and in-person) indicates the lack of confidence and experience in similar situations, much aggravated by COVID-19 pandemic situation, which in general, did not allow training assertive communication and other very important skills for their professional future.

## V. Conclusion

PBL emerged as the ideal methodology for this case study, which allows all to look at the problems from different angles, attesting to urgent mindset changes and providing all kinds of Women with ICT inclusion. With this article, it was possible to understand how technologies are perceived, in terms of gender identity and equality and in the development of their research themes (carrying out a burden of prejudices) reflected in their theoretical and practical work.

Another constraint highlighted is the lack of experience in public communication, in face-to-face interventions, the intervention made by women were very problematic (more complicated in recorded online classes) which often reflects the lack of logical coherence and little self-confidence, that most of these students suffer from the first to the last year of graduation.

Through women's words, it was possible to prove evident and current misunderstanding perceptions of gender inequality, perceived by the twelve female students in Computer and Multimedia Engineering degree courses, in the 2020/21 academic year, and the long road that still remains to be covered. Women must portray what they really want and feel, they must feel truly included and welcomed in the technological field of knowledge, in

lifelong learning and in the development of their lives and professional future, but what is the key to doing it?

Some achievements were women's thoughts' importance and relevance to value-added in technology and multimedia creation. Even during the period of analysis of all categories, one of the female students changed her research theme and create a website about Women in ICT and other female students realize, that using the best of her knowledge to find how to program and design a classic game by herself, without any help, actually made a huge difference for self-improvement.

Some conclusions are set out below and could provide more transdisciplinary communication in PBL practical activities, which can be extended to students with a lack of socialization and problematic relationships, people with handicaps, mental and physical disabilities, and increasingly new forms of interaction and references.

According to female students, core curricular units of the undergraduate, graduate, master's and postgraduate courses should create real challenges with PBL methodology, similar to professional context, since classes began, worthing more in terms of assessment than the final tests. Another crucial future investment, according to their answers, could be formal training, informal and non-formal training actions investment, which should reflect knowledge evolution, with the possibility of linking and exchanging experiences with the surrounding community and worldwide. Furthermore, this case study coincided with the recent Erasmus Coordination Research Group e-Women in ICT at ISTE (Enhancing Skills to Bridge Digital Divide) which will possibly change some of the procedures in short term worldwide, and who knows, people's mentalities.

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