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*Research Article*

# Teaching Gender for STEM Scholar Community in a Virtual Learning Environment: A Path for Scholar Digital Transformation

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**Abstract**

This paper presents a Virtual Learning Environment as an axle for teaching and learning Gender topics in a Science, Technology, Engineering and Mathematics scholar community. The Virtual Learning Environment has been developed in Moodle, considering the syllabuses to teach the subject in the Faculty of Engineering at Universidad Nacional Autónoma de México. Teachers, researchers, and students made the design with specialization in pedagogy, gender, computers, and systems. The methodology includes a literature review of pedagogical methods, gender topics and dynamics, and educational technologies. The integration of constructivist methodology helps to focus on tasks or problems, encourages research, and formulates strategies for their solution; it was possible by considering two pedagogical methodologies: thinking-based and problem-based learning. Using a Virtual Learning Environment is ideal for promoting the integration of multidisciplinary teams. In this case, the pedagogical design incorporated the Gender Perspective and gender violence as cross-cutting issues to be addressed according to the agenda of a subject on gender. Considering these elements, activities, readings, and evaluations were designed and incorporated into a virtual classroom in Moodle. Underlying the findings found in this project, it is essential to mention the development of content with a gender perspective within STEM areas and the development of an easy-to-learn technological platform under a didactic and innovative methodology.

**Keywords**: Virtual Learning Environments, Digital Transformation, Higher Education.

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## Introduction

Equality in the incorporation of women in the labor, political, and educational spheres is an issue awaiting national and international agendas; Universidad Nacional Autónoma de México (UNAM) is not exempted from this problem. In Mexico, facts and replies associated with gender violence have been increasing, becoming visible through protest acts, denunciations, and strikes, among others. Álvarez-Enríquez (2020) affirms that feminists place at the center of their discourse the demands and debts of women who have experienced the effects of patriarchy over time. Sánchez (2020) mentioned: there are alarming numbers of femicides; in addition, they are linked to all social and educational levels. It has been evidenced by multiple cases of violence reported at the universities.

The Office of the General Attorney (2020) established UNAM with a University Program for Gender Studies in 1992 as an academic need. However, UNAM has registered constant complaints and diverse student movements. At UNAM, Álvarez-Enríquez (2020) mentioned that the voices and demands of female students were manifested, promoting activities and demonstrations against gender violence.

In consequence, throughout the last few years and in response to the community claims, attention to gender issues among the university community has increased. A necessary action was that UNAM designed a Protocol for the Attention of Cases of Gender Violence (developed from 2007 to 2015).

In it, various legal mechanisms were set out to address cases institutionally. The Protocol presents the principles of action, as well as the identification and characterization of the acts that should be considered as gender violence, setting out examples in this regard; in turn, the functions and obligations of the authorities, instances, and roles of the different actors involved in the attention of cases of gender violence are established as stated The Office of the General Attorney (2019). The Coordination for Gender Equality (CIGU by its acronym in Spanish) was created in 2020 and is the "university body in charge of designing, promoting, and coordinating university policies on gender equality" at UNAM, as established by CIGU (2023). Another relevant action has been integrating compulsory courses on gender violence issues into the curricula of some degree programs.

## Methodology

The methodology for the development of VLE is illustrated in Figure 1.

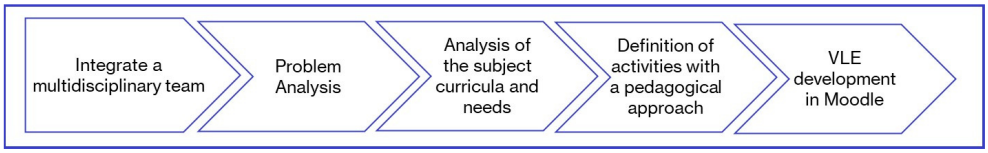


**Figure 1. Methodology for the development of the VLE**

Based on this methodology, a practical and innovative proposal was generated because: (1) there has been relatively little time in the incorporation of courses and subjects with a Gender Perspective in UNAM's study plans and programs since the institutional document that governs the University's gender policies was created in the year 2022 as CIGU (2022) observed; (2) not all teachers and projects created on gender issues have expertise in Information and Communication Technologies (ICT) development areas and pedagogy specialists; having a multidisciplinary approach in areas that address gender and science-technology-engineering issues is new. This work allows us to have a digital environment model that formally encompasses gender issues using an ICT tool widely tested and used worldwide, such as Moodle.

## Gender Issues at the Faculty of Engineering, UNAM

The Faculty of Engineering (FI) has been part of UNAM since its creation in 1910. In 1921, four women were enrolled; it was not until 1930 that

Concepción Mendizábal graduated as the first woman with an engineering degree. For many years, the student community comprised an overwhelmingly male population, generating a predominantly male culture and values. With the creation of new degrees and time, the percentage of women has increased, representing 27% of the student body.

However, even today, enrollment still shows significant differences between degree programs, as shown in Table 1.

**Table 1. Population of men and women by undergraduate degree at the Faculty of Engineering, UNAM, where the symbol * refers to degrees with admission in semesters after the first semester. Data from: Statistical Agenda, UNAM (CGPL-UNAM, 2023).**

| Academic Entity / Degree | First semester | | Re-entry | |
|---|---|---|---|---|
| | Men | Women | Men | Women |
| ***Faculty of Engineering*** | ***74%*** | ***26%*** | ***74%*** | ***26%*** |
| 1. Aerospatiale Engineering | 70% | 30% | 64% | 36% |
| 2. Environmental Engineering | 35% | 65% | 27% | 73% |
| 3. Civil Engineering | 80% | 20% | 79% | 21% |
| 4. Mining and Metallurgy Engineering | 83% | 17% | 71% | 29% |
| 5. Electronic Electrical Engineering | 80% | 20% | 84% | 16% |
| 6. Computer Engineering | 72% | 28% | 79% | 21% |
| 7. Biomedical Systems Engineering * | - | - | 52% | 48% |
| 8. Telecommunications Engineering * | - | - | 76% | 24% |
| 9. Geophysical Engineering | 77% | 23% | 65% | 35% |
| 10. Geological Engineering | 53% | 47% | 53% | 47% |
| 11. Geomatics Engineering | 71% | 29% | 70% | 30% |
| 12. Industrial Engineering | 60% | 40% | 59% | 41% |
| 13. Mechanical Engineering | 85% | 15% | 82% | 18% |
| 14. Mechatronic Engineering * | - | - | 82% | 18% |
| 15. Petroleum Engineering | 78% | 22% | 75% | 25% |

The FI offers 15 engineering degree programs: mechanical, electrical-electronic, civil, computing, industrial, mechatronics, biomedical, aerospace, geomatics, environmental, geological, telecommunications, geophysics, and petroleum. Figure 2 shows the population of the Faculty of Engineering by gender during the first semester of 2023. That semester, 74% of the male students enrolled, while 26% were women. The figure also shows that Environmental Engineering has a much larger population of women than men. At the same time, Biomedical Systems Engineering and Geological Engineering tend to be composed of a population equal in number. However, in most careers, the population is male, with electrical-electronic engineering, mechatronics, and mechanics being the most unequal in such a way that the total population is made up of 74% men and 26% women.

Similarly, the teaching staff comprises 27% women and 73% men, according to UNAM Statistics (2023). The predominantly male composition of the FI has historically led to attitudes of discrimination toward women, as illustrated by Eng. Leda Speziale in her stories about her journey through the 1940s as a student (UNAM Chicago, 2022). In the literature, it is possible to find testimonies of students and teachers who were discriminated against or reviled for being part of the FI community (Escamilla & Pineda, 2010; Soto, 2018; Editorial Telediario, 2018; Maldonado, 2018). Furthermore, it was not until 2020 that, for the first time, a woman headed the Institute of Engineering, Dra. Rosa María Ramírez, while in the FI, a woman has never managed the school, as institutional websites show (IIUNAM, 2020; FI UNAM, 2023).

During 2021, the authorities and the community discussed the need to change the gender culture and, in this sense, incorporate courses as part of the study programs, as mentioned in AGFI's documents (2021). It was agreed to create a mandatory subject on gender issues focused on Engineering students. Therefore, in the FI, the subject "Gender equality in engineering" was taught for the first time at the end of 2022, and, at the end of the year, it will have been prepared for the third time for all newly admitted FI students.

The schedule was developed with the participation of the Internal Commission for Gender Equality and members of the CIGU at UNAM. It is a subject with a duration of 32 hours, in which five topics are developed: 1. Introduction to the basic concepts and principles of gender; 2. Gender violence, 3. Masculinities, 4. Sexual division of labor, 5 Feminized subjectivities in science, technology, engineering, and mathematics (STEM).

**Virtual Learning Environment (VLE)**

In addition, the need to have open-use virtual tools for school communities has become clear since the COVID-19 pandemic. In this sense, it was decided to develop a VLE in Moodle for teaching this gender program, considering the thematic and pedagogical aspects, in such a way that Viteri et al. (2021) stated that they allow the incorporation of an educational practice with more diverse and innovative activities that impact the quality of teaching and student training.

This decision also contributes to the institution's path towards digital transformation. Kopp et al. (2019) define digital transformation as the sum of the digital processes essential to achieving the transition of higher education institutions, resulting in better use of digital technologies. Strohmaier et al. (2019) and Zinchenko et al. (2020) detailed that technological transformation involves modifying the processes and organization of interconnected activities and subsystems.

The OECD (2018) has established that “Digital transformation refers to the economic and social effects of digitization and digitalization. Digitization is the conversion of analog data and processes into a machine-readable format. Digitalization is the use of digital technologies and data and their interconnection, resulting in new or changed activities”.

In this way, VLE does not consist of transferring teaching from a physical classroom to a virtual one. It is required that all available technological resources be known, such as infrastructure, media, information resources, and others, as well as advantages and limitations to relate them to the objectives, strategies, contents, and learning and evaluation activities. The incorporation of capabilities in the use of ICT for remote work and collaboration in networks represents a challenge to be incorporated as part of the training of university professionals, given that, as UNESCO (Valencia-Molina, 2016) states, the transition from an educational model typical of an industrialized society to an educational model marked by the demands of a computerized society is a process that most institutions worldwide are experiencing. VLE is characterized by being information spaces designed for educational processes; educational interactions occur there; they represent the classroom and can vary from text to immersive 3D worlds; in addition, students are also actors who co-construct the virtual space through their participation, can be used to enrich face-to-face activities since they integrate heterogeneous technologies and multiple pedagogical approaches as Dillenbourg et al. (2002) declared. Most VLE intersects with physical environments.

To facilitate teaching on gender issues in the Faculty of Engineering and at UNAM, a VLE for hybrid education has been designed following the syllabus, reality, beliefs, language, and other characteristics of engineering.

**Virtual Learning Environment for Gender Equality in Engineering**

The VLE was developed considering the syllabus of "Gender equality in engineering," the Moodle platform, and the constructivist methodology that focuses on tasks or problems, encourages research, and formulates strategies for their solution. A research team has been integrated with experts in gender issues, pedagogy, and software development on Moodle platforms who, together with four students of engineering and pedagogy, developed the VLE. In addition, the subject teacher at FI-UNAM is part of the team.

Thus, a literature review was carried out, including the texts recommended for teaching the subject. Dynamics corresponding to the five major themes of the study program were chosen and modified. For the development of VLE, the Thinking-Based Learning methodology was considered; it supports that students should be

able to analyze a problem and construct and compare possible solutions by listening to other classmates, allowing for individual enrichment of the solutions found and collective enrichment of the general results. Swartz (2014) mentioned that by comparing and contrasting, it is possible to find new solutions that are even more comprehensive and complete. This methodology is suitable for developing ICT content since it focuses on students acquiring skills, attitudes, and knowledge using real-life situations. This approach is transformative for students because they build and face daily situations different from those experienced by previous generations. In this sense, the cases offered reflect this reality, covering problems directly related to the students. Documenting the analysis and exposition of the information using Moodle, where the theoretical and practical contents are centrally located, helps the student gather everything in a single ordered repository. In this way, they can support their answers, not only from experience but also theoretically.

The second pedagogy methodology to design the VLE is the Problem-Based Methodology, PBL. In this sense, activities have been included where, through questioning, the problem is constructed or related problematic situations are exposed for analysis. Even though these are complex problems, proposals for individual and social change are requested to implement critical thinking, focusing on collective learning processes with a constructivist approach, establishing five steps: identify, deepen, list, evaluate, and scrutinize in the classroom. In turn, Quintero (2017) affirmed that this methodology incorporates ICT, a crucial element for the proper functioning of the course, used to organize and present information and didactic resources creatively and ergonomically, thus facilitating the interaction between each technological component involved in developing the topics.

By combining both methodologies, we obtain a method such as PBL for the analysis of problems where critical thinking is put at the center, promoting, in turn, communication skills among the participants of each group, enabling the process of learning associated with the teaching-learning process. Quintero et al (2017) mentioned in "Development of Critical Thinking through the Application of Problem-Based Learning'' that the active participation of the students helps in the interaction of work groups since each student will contribute, given previous knowledge and life experiences, a perspective that may have characteristics of coincidence with the others and at the same time analyze the differences, thus promoting the plurality of ideas, the analysis of what is being presented, and the ability to transmit information clearly to give rise to the justification of such statements or proposals. Thus, critical thinking is a competence that students must develop and strengthen, which is of utmost importance for their formation as students and in the future as professionals.

Incorporating both methodologies for the teaching-learning process allows the use of PBL as the central methodology of the process and the Thinking-Based Learning methodology to promote the student's critical thinking centrally. On the other hand, acquiring knowledge in the teaching-learning process must be of quality; according to Bokova (2015), this should be "the engine of sustainable development and the key to a better world." The VLE design places the learning not only on the individual but also on a collective character. In the area of gender, combining the methodologies described above to raise and analyze complex problems is innovative. It could be part of the competitive and sustainable solution to improve quality in university contexts.

It is worth mentioning that these methodologies also contribute to providing teachers with new skills and competencies. The traditional model, the most common at FIUNAM, where the teacher dictates the class and evaluates, is replaced, as Sanz (2018) cited, by a series of new meanings in a changing society in which the role of the teacher is also modified:

- Being an agent of change and not just an "exhibitor." The teacher represents a guide for the students, motivating the acquisition of knowledge, its construction, and reflection.
- To be seen as trainers of people in the instructional part, that is, as promoters of free, critical, responsible, and integral generations.
- To be recognized as figures of proactive, positive attitudes with ethics, teachers will be responsible for awakening curiosity, autonomy, and intellectual rigor, promoting the formation of students by example.

- Constitute themselves as a guide to help students seek, find, organize, and manage the required knowledge, considering each student's rhythms and learning methods.
- Start the discussion of the topics, formulating questions and unknowns about the issue to be studied. In this way, the class does not start with definitions, theorems, and axioms, among others, but with questions that will guide the class discussion to generate triggering questions that, in turn, allow the search and exposure of individual and collective reasoning. The following describes the activities proposed at the end, the leading gender topic to which the activity is related. Most of them were estimated to be carried out in 120 minutes, that is, a complete class session, except for the topics of sexual division of labor (60 minutes). All activities were designed considering the thinking-based learning and problem-based learning methodologies; they can be regarded as independent and thus achieve a flexible proposal. The teacher can decide whether to use all the activities or a part of them, follow the suggested sequence, or resume them with another arrangement.

1. ***Expectation vs. reality.*** The behaviors that society and ourselves as individuals expect from a couple are questioned and confronted with our behavior. Through this activity, students construct and discuss the models and stereotypes of families in the past from their perspectives. Masculinities.
2. ***Reading about masculinities.*** A short reading on masculinities is given, and questions are asked for discussion in teams and plenary. The lesson presents a classification of masculinities, and the students consider the possibility of intervening in social problems such as gender attacks and discrimination. The problem that arises is: does hegemonic masculinity have negative consequences? Violence, economic and emotional demands, repression, suicides, and deaths are raised. It concludes with a reflection on the new masculinities. Masculinities.
3. ***There are many ways of being a man.*** Based on film and television characters, the archetypes of masculinity are recognized. Subsequently, characters with disruptive and egalitarian characteristics are sought. The role of masculine figures promoted by the media, family, and social environments and the demand to comply with the stereotype are questioned. The emergence of other male statistics is discussed. Masculinities.
4. ***Violence to non-hetero-normative groups.*** Through two selected videos, participants are questioned about the attitudes and actions that can be taken individually to achieve equality in gender diversity. Gender violence.
5. ***Song analysis***. Gender and behavioral messages are analyzed through pre-selected songs. The contents and effects of the messages through mass media are discussed—gender violence.
6. ***Analysis of phrases and situations***. Messages of violence are analyzed through phrases commonly used in our environment, and the effects of family and social use of these messages are considered—gender violence.
7. ***Knowing the Protocol of Attention to Cases of Gender Violence of the UNAM***. The Protocol is presented by analyzing known situations in the university environment: gender violence and UNAM protocol. The instances and protocols at UNAM are disseminated.
8. ***Job, why do I have to do this?*** - The distribution of household tasks and stereotypes to decide the assignments are analyzed—sexual division of labor.
9. ***Differences and similarities***. Various professions and occupations and related gender stereotypes are analyzed—sexual division of labor.
10. ***Concepts you should know***. Research and discuss concepts such as the glass ceiling or sticky floor to learn about gender problems at work—sexual division of labor.
11. ***Names of women and men scientists***. The knowledge of people who have contributed to science according to their sex is questioned, evidencing men are most known STEM.
12. ***Female scientists.*** The contributions of women scientists in STEM areas at a national and international level are investigated. It is discussed whether there

have been women who have contributed to science and why it is difficult to remember them. STEM.

13. ***Identifying violence in STEM***. Through the cases described, the types of violence raised are identified. In the STEM careers where students are involved, attitudes, inequalities, and consequences are reflected.
14. ***Introductory concepts of gender equality and equity***. Concepts such as discrimination or patriarchy are analyzed from the knowledge and experience of the participants.
15. ***Categories of sex-diversity.*** The different sex-gender categories are identified through a group dynamic—introductory concepts.
16. ***Dialogue circle - What bothers you?*** A reflective conversation about social pressures and individual concerns about stereotype compliance is held—introductory concepts.

All activities were designed to encourage the active participation of students while promoting communication skills among the participants and to obtain didactic evidence at the end of the session. The Moodle platform environment was designed with an attractive graphic design and web navigation. Table 2 summarizes the steps of the constructivist process involved in each activity intended.

**Table 2. Activities are included in the VLE, and pedagogical emphasis is in each.**

| Activity | Problem identification | Deeping | Enumerate | Evaluation | Scrutinize |
|---|---|---|---|---|---|
| 1. Expectation vs. Reality | Social demand | Social changes and self-assessment | Relevance of the required characteristic to one's reality | Are changes possible? | |
| 2. Reading about masculinities. | There is a role model for men to follow | Should the model be observed, or are there others? | Problems due to changing the model | Is it worth changing? Are there consequences of following the imposed model? | |
| 3. Many ways of being a man | Characters and gender characteristics disseminated by the media | Characters with new behaviors | | What kind of man am I? | |
| 4. Violence to non-hetero-normative groups. | Violence towards people with different characteristics | Why are they assaulted? Are there other ways of relating? | Discriminations and motives | Actions that can change the relationship between people | What would I change? |
| 5. Song analysis. | Behaviors and characteristics in popular songs. | Do they promote ethical behavior and influence social behavior? | | Are there songs with messages of equality? | |
| 6. Analysis of phrases and situations. | Sayings, proverbs, and phrases against women | Do they influence men's behavior? | | What would I change from my direct environment? | |

| | | | | | |
|---|---|---|---|---|---|
| 7. Knowing the Protocol of Attention to Cases of Gender Violence of the UNAM. | Violence and Femicide in the University | Gender violence in my immediate environment | Actions in a violent situation | Know the basics of how to react to violence | Complaints, school, and administrative consequences |
| 8. Job, why do I have to do this? | Is there a reason to split the labor? | How is the work distributed in my household? | Are there differences in formal labor? | What household chores did you perform and why? | Would I like to perform other domestic tasks? |
| 9. Differences and similarities. | Is all work remunerated? | Are there consequences of not paying for work? | Why is certain work valued and others not? | What would happen if it is not performed? | Proposals to achieve employment equality |
| 10. Concepts you should know. | | Conceptual review | | | |
| 11. Names of women and men scientists. | Do you know men and women engaged in science? | Why do you know so few female scientists? | Are there gender differences in the performance of intellectual work? | | |
| 12. Female scientists. | | The work of Mexican and international women scientists is disseminated. | | | |
| 13. Identifying violence in STEM. | Cases are presented | The type of violence is analyzed and listed | Actions to be taken in response to the cases | | |
| 14. Introductory concepts of gender equality and equity | Conceptual review | | | | |
| 15. Categories of sex-diversity. | What are the categories? | Are there differences among the categories? | | | How can we promote respect for differences? |
| 16. Dialogue circle. What bothers you? | Identifying social pressures | Do I have to comply with the stereotypes? | | Could I change, or must I comply with the requirements? | |

To illustrate one of the activities, two responses to the activity on "Expectation and Reality" have been chosen. In it, students in teams were asked to list the ideal characteristics of a man and a woman in grandparents' times and then in current times. They listed all the features and opened the discussion to understand the elements and the changes between epochs. They were asked if they met the characteristics described, and the general response was that they considered they did not meet even 50% of the traits listed. See Table 3.

**Table 3. Examples of student responses to the activity: Expectation vs. Reality. It was taken from the Gender Equality class taught at FIUNAM, semester 2024-1.**

| **Grandparents' times** | | **Current times** | |
|---|---|---|---|
| ***Man*** | ***Woman*** | ***Man*** | ***Woman*** |
| With money, hard work, land, strong character, stocky, formal, with inheritance. | Childbearing, fertile, virgin, submissive, beautiful, religious, faithful. | Tall, fair complexion, with money and material goods, emotionally stable, respectful, athletic, non-fifty, self-sufficient, no children. | Emotional stability, studious, physically fit, respectful, intelligent, self-sufficient, faithful, childless. |
| Mustached, strong, tall, white. Courageous, masculine, leadership, elegant, self-sufficient, strong character, manly. Hard-working, with heritage, with possessions. | Pretty, tall, fair complexion, very feminine dress, fertile. Virginal, feminine, submissive, loving, attentive, homely, faithful, responsible, religious. Wealthy parents with dowry. | He has a job and is financially stable, respectful, gentlemanly, intelligent, educated, tall, muscular, with his car, hygienic, and charismatic. | Beauty, slim, faithful, studying or working, with goals in life, economically does not matter, religion does not matter, sportswoman, responsible, with values, reliable and hygienic. |

The following is a student reflection result that shows the development of critical thinking associated with the teaching-learning process: Throughout history, the standards and idealizations of women and men have undergone significant changes that reflect the cultural, social, and economic transformations of each era. These changes not only reveal how society has evolved in its perception of gender but also how expectations around roles, appearance, and behavior have changed. Standards and idealizations of women and men have evolved in response to cultural, historical, and social changes. While there is still work to be done to achieve gender equality and the elimination of stereotypes, we are on a path toward a broader and more respectful understanding of gender diversity and individuality.

To conclude the activity, students were asked to evaluate it. Here is one student's response: I learned that men's and women's roles have changed throughout history and depend on what society accepts as right or wrong. I liked working in teams to know my classmates' opinions, although I feel that we did not say everything we thought for fear of being judged. I liked the dynamic, but it would have been complimented if we had women.

## Conclusions

This project contributes to generating consciousness of gender violence, including the gender perspective in its plans and programs to influence cultural changes in the university environment, betting on long-term change in the university. Another contribution of this study is

that this course has been designed considering the characteristics of the population in the STEM area, particularly in the Faculty of Engineering.

Building knowledge using the PBL methodology helps students to analyze problems; in this case, exposing cases on gender allows them to learn using experiences, knowledge, and information presented. In turn, it will promote soft skills by putting the student in an environment where they must learn to use appropriate and clear language to express their ideas, support them through the content of the course modules, and interact with their classmates. They can analyze what they are exposed to and defend their views with respect and empathy, allowing for assertive communication, teamwork, adaptability to the environment and change, prioritizing tasks, and problem-solving issues.

Regarding the work methodology in the project per se, a VLE was used. This methodology is ideal for promoting the integration of multidisciplinary teams. In this case, the pedagogical design incorporated the Gender Perspective and gender violence as cross-cutting issues to be addressed according to the agenda of a subject on gender, which is part of the curriculum of the degrees offered by the FI. Considering these elements, activities, readings, and evaluations were designed and incorporated into a virtual classroom in Moodle.

It is important to emphasize that at the time of writing this article, no gender courses in VLE in STEM areas were found, so this project contributes innovatively to introducing the gender perspective in these areas.

The gender VLE is aligned with UNAM's gender equality policy. In this sense, it echoes the need for specialized training of human resources in these issues, resources that become spokespersons and trainers of more human resources, and adapting the ICT at each stage in designing and delivering courses for better and broader dissemination.

We are implementing the course using both the ICT and the teaching methodology, testing and documenting the findings and areas of opportunity generated by hybrid teaching. In the immediate future, the course will be delivered face-to-face and use the support of the gender VLE.

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