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CHALLENGES IN TEACHING OF RENEWABLE ENERGIES IN A DIGITAL WORLD DURING COVID-19

From face-to-face to remote learning in Colombia

Retos en la enseñanza de las energías renovables en un mundo digital durante la COVID-19. Del aprendizaje presencial al aprendizaje remoto en Colombia

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KEYWORDS

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ABSTRACT

The COVID-19 pandemic-induced worldwide contingency has significantly disrupted the way education has been delivered, going through a crucial period of change and adaptation. But how does this dynamic impact both students' and teachers' educational process? This research on the teaching of renewable energies at the higher education level in engineering programs reveals the main challenges to this transformation as well as how they were overcome. The methodology is qualitative with two-way dynamic reflection, between the facts and their interpretation, and impacts 130 engineering students, from all of Colombia's regions. Among the main results, six challenges stand out, which were addressed through different strategies.

PALABRAS CLAVE

Educación Superior
Aprendizaje Remoto
COVID-19
Desarrollo Sustentable
Energías Renovables

RESUMEN

La contingencia mundial causada por la pandemia de COVID-19 ha alterado significativamente la forma en que se imparte la educación, atravesando un período crucial de cambio y adaptación. Pero ¿cómo impacta esta dinámica en el proceso educativo de estudiantes y profesores? Esta investigación sobre la enseñanza de las energías renovables en el nivel superior de programas de ingeniería revela los principales desafíos de esta transformación y cómo fueron superados. La metodología es cualitativa con reflexión dinámica bidireccional, entre los hechos y su interpretación, e impacta 130 estudiantes de todas las regiones de Colombia. Entre los principales resultados destacan seis desafíos, abordados a través de diferentes estrategias.

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1. Introduction

Energy supply is one of the most important human needs of this century in such a way that almost all anthropic activities are based on energy (Buchmayr et al., 2021; Martínez and Ebenhack, 2008). The main source of energy supply worldwide has been fossil fuels for many years, and their exploitation and energy conversion process has generated consequences at an environmental, social, economic, and political level, such as the accelerated emission of greenhouse gases (GHG), pollution, acid rain, global warming, climate change, poverty, and inequality (Hoppe et al., 2016; Koraz & Gabbar, 2017).

For its part, given that one of the most important indicators of the growth and development of a country is associated with its level of energy consumption, especially in industrial and technological processes (Guven & Sulun, 2017; Karabulut *et al.*, 2011; Balmaceda *et al.*, 2019), the problem has increased in recent years, so that today it transcends, and the need to join global efforts by the State, industry, and academia to mitigate it is evident (Lee *et al.*, 2016). This has led to setting up different decisive moments for the implementation of solutions, where all nations begin to take sides from different perspectives, in a common position "the construction of a more sustainable and environmentally-friendly society". This is how different treaties and protocols were signed, the Sustainable Development Goals were established, and awareness has been raised about the need to educate on the use and exploitation of energy and its different sources (United Nations, 2015).

The most developed societies have generated more environmentally friendly ways of living through the implementation of cleaner production processes, the construction of more efficient vehicles with lower GHG emissions, the protection of natural resources, and the generation of environmental awareness in their habitants (Zhu *et al.*, 2020). This is justified not only by reasons related to climate change and its consequences, but also by the clear depletion of fossil sources, given that the cost of producing energy is increasing, and its associated processes are more difficult to execute (Garzón and Bellon, 2021). All this investment in the search for more environmentally friendly forms has led to the research and development of alternative energy sources such as wind, solar, biomass, and hydrogen, among others; which have advantages over conventional sources, such as no GHG emissions, easy use, wide availability as they are renewable resources, and the growing boom in the development of technologies for their use (Kuik *et al.*, 2019; Patchell & Hayter, 2021).

This context has led this type of society to implement policies aimed at an energy transition, where the State, industry, and academia take part with great synergy. One of the most important key activities to achieve this goal corresponds to the formal and informal education of its inhabitants, for the development not only of technical knowledge associated with the development and use of these technologies but also the generation of awareness of the problem, the urgency of solution and need for active participation of each individual as a member of society (Acikgoz, 2011). For this reason, energy education should be introduced at the different levels of the primary, secondary, university, and other academic institutions (Kandpal & Broman, 2014), so that students identify the importance of their role in generating solutions strategies, based on the recognition of the current energy crisis, conventional and non-conventional sources of energy, the design, development, and use of the technology involved, national and international guidelines at the political and economic level.

In Colombia's case, it has been shown that education in basic knowledge related to the subject is insufficient, if not null and that this same behavior is applied to the recognition of the energy crisis and its impact on daily life. Similarly, the problem is accentuated by the global contingency caused by the pandemic, where education went from face-to-face to remote, in institutions that did not have the minimum conditions to face the challenge, where in addition illiteracy in digital competence of both teachers and students is evident, recognizing that this transcends the training and use of ICT as an instrument (Pérez-Mateo *et al.,* 2014).

Considering the above, as well as the improvised remote education of higher education institutions (HEIs) in Colombia, and the digital age in which university students live, the challenges in teaching renewable energies in a digital world at higher education level in Colombia are presented. Similarly, we present the way in which these challenges were approached and overcome from the rethinking of the curricular, pedagogical, didactic, and evaluative aspects of the subject. These results cover the experience, efforts, and finally challenges in the transition from face-to-face education to remote education.

2. Literature review from the lenses of education in a digital world

The global contingency generated by the COVID-19 pandemic has caused a massive disruption in the way education has been delivered, going through a critical moment of change and adaptation (The Lancet, 2020). This is how all the educational institutions have wanted to reorganize in three stages: an initial one totally devoid of preparation, where the students returned to their respective homes in a process of social isolation and preservation of public health; a second stage, which has been carried out slowly without the expected success, characterized by alternation and social distancing; and a third stage, uncertain, where the new forms and pedagogies will be

definitive, and "the new normality" will be established in education (Iglesias-Pradas *et al.,* 2021). But how does this dynamic affect the educational process for students and teachers?

Addressing this question implies considering that education is a specifically human phenomenon, historically showed in its concern to achieve excellence ("areté") through "paideia"; however, this teaching of "areté" has evolved historically, and with it the real purpose of pedagogy. Thus, for the sophists the "areté" of man and with this the aim of education, focused on language, focusing on the imposition of individual opinion, and demonstrating that one was right through training in discourse and the persuasive power of the "lógos" (word, reason). Subsequently, Isocrates introduces rhetorical humanism, where he assumes the pedagogical task as a means of balanced and broad training in the conscious and responsible use of language to become a man and citizen of the "polis", focusing on the human capacity to choose and build their own lifestyle, traditions, and their life in society in a free and rational way (Bohm, 2010). This is how some people can attribute to the sophists the creation of pedagogy as deliberate and conscious practice or action, as well as the fact of focusing attention on human and political problems (Ramírez Hernández, 2014).

On the other hand, Socrates introduces the first approach to the conception of education as a liberating action of man for himself, inviting reflection on what is common in the assumption of responsibility for the organization of his own life. Next, Plato conceives pedagogy as the conversion and transformation of a man as a whole, which will allow him to govern his own life, and sociopolitical community life. In turn, the Stoics re-signify the concept of "areté", as the harmony between nature and man as the ultimate goal of all human aspiration (Wang *et al.,* 2008).

As history progresses through Judaism, Christianity, the Renaissance, the Enlightenment, and all the milestone epochs, the concept of pedagogy evolves, and the basis of knowledge is widely discussed, with reliance on human reason being argued, the need to conceive of man as a natural, moral, and social being. Likewise, the purpose of education evolves, highlighting different questions of "true education" such as the emancipation of man, the conservation or construction of his identity, and the assimilation of cultural heritage, among others. The truth is that, from its different interpretations and structures of thought, history links its pedagogical thought with ancient roots, conceiving pedagogy as an enlightening and emancipatory formation of man through the search for knowledge and truth, which takes its point starting from an internal self-awareness, and a process of critical formation of consciousness, in a coherent effort to achieve an awakening towards a better social and political practice, but without losing its identity. In this same way, it recognizes that the individual changes his environment and in turn it modifies him, transforming that flow into social progress, supported by the human characteristics of reason, freedom, and language, which in turn allow a realization of man (Bohm, 2010).

This is how education does not exist to produce subjects that are clearly adaptive to the social, economic, political, and cultural demands of the environment. Instead, what is necessary is a cultural and educational system oriented towards creative exploration, independent thinking, promotion of free questioning of preconceived ideas and beliefs, and an educational process that trains subjects with the ability to face the environment critically and constructively, projecting transformations in it (White Pole, 2018). However, the XXI century society is in a crisis of civilization, which has vitiated the ultimate purpose of education, permeating different areas of humanity, characterized by a new acceptance of "values" and lifestyles adapted to a market economy -a market that does not conceive the human being as such, but as one more consumer-. In this regard, Reales and Gamboa (2021) have shown that, chronologically, the traditional school has been thought of as a fragmentary project: initially from the civilizing and nationalizing plane, later from a religious plane, to finally arrive at a scientific and modern conception from a logocentric character. This new vision means that in institutions -especially IES-, the student is conceived not as what he is - "the center and engine of the educational process, who gives life to the work conducted by the educator, who only guides or eases their learning through joint and transformative action. The learner should no longer be a "domesticated" and "manipulated" entity but a manager of its transformation" (Freire, 1985)-, but as a client, a vision that corrupts and perverts the educational purpose, reducing it to the production of people -as one more resource - for the market.

On the other hand, the cultural effects of the acceleration of world time and changes resulting from new technologies have become an alternative for the development of a debate process in which people see themselves as part of a group, they learn to respect differences of opinion and tolerate them, strengthening the ability to seek understanding and thus have an impact on educational processes (Villa-Vélez, L. *et al.,* 2021). This is how the development of platforms provided by Information and Communication Technologies, and the Internet as the mesh that supports the fluid circulation of information, have changed the relationship between the human brain and computers (Schultz, 2007). This development has an impact on new formats, expansion of times and spaces, as well as potentization of non-formal models of construction of knowledge and teaching-learning processes (González-Sanmamed *et al.,* 2020). Similarly, He and Li (2019) point out that technology has made learning increasingly self-directed and informal, blurring the line between formal and informal learning.

This change in the dynamics of the educational process, marked by ICTs, the global contingency resulting from the pandemic, and society's own conception of the purpose of education and student training, accentuates this crisis of civilization, which finally permeates not only the real purpose of education and the means of building

society but also increases the disinterest of students in their training process, hindering the work of the teacher in the classroom, since the student is the central part of the process.

3. Literature review from the lenses of energy education

The report of the World Commission on Environment and Development "Our common future", highlights the role of the teacher as a primary element in the construction of social welfare, from the understanding and dissemination of policies associated with the environment and development to the role of each subject in the environment and its link with sustainable development. However, this same report also highlights the need to improve the quality of education and its relevance to the context of the students and emphasizes as a critical point the different challenges that the teacher faces, starting from teacher training, support to curricular development, preparation of didactic material, need to increase collaborative work at a national and international level (especially with specialized centers), among others (World Commission on Environment and Development, 1987).

In this same context, the construction of knowledge does not occur only by having locative adaptations for teaching but also needs to face different challenges (additional due to the pandemic), such as the formation of the student as a being and not as another market resource, the teacher's own training to achieve real knowledge and the development of skills that lead students to question the social, environmental, political and economic reality, to develop an awareness of their role in society and finally, to propose solutions in the same direction. However, all this needs a transversal curricular design at all levels of education. This is how Tara Kandpal and Lars Broman (2014), make a global review of education in renewable energies, highlighting the importance of including the subject at distinct levels (schools, colleges, universities, and other academic institutions). As a result of this work, the authors establish a relationship between the different levels of education and the modalities or types of programs that should be implemented, as shown in table 1.

Table 1. Potential education levels in renewable energy

Age Group	Institution	Modalities / Types of programs
5-10	Primary school	Introduction of simple concepts within the topic of environmental studies and/or associated relevant topics.
10-13	Secondary school	Introduction of relevant concepts and demonstration experiments in the science curriculum.
13-16		-Introduction of relevant concepts, demonstration experiments in science and biology curriculum. -Introduction of pre-professional courses in the field of renewable energy technologies.
15-18		-Introduction of relevant concepts, technologies, demonstrations and laboratory experiments in Physics, Chemistry and Biology curriculum. -Introduction of professional training courses in the field of renewable energy technologies.
>17	Technical colleges, polytechnic colleges, engineering colleges, technological institutes	-Certificates and diploma level programs for technicians and mechanics. -Undergraduate and graduate programs. -Short-term training courses to update knowledge and skills.
>25	Any suitable institution	Mid-career courses, updating for technicians, installers, and other professionals.
Any age		Awareness and sensitization programs for government officials, policymakers, administrators, and the public.

Source: Adapted from Kandpal and Broman (2014).

When making a deep analysis of the contents and teaching of renewable energies worldwide, an alignment with the modalities proposed for primary and some the secondary level is found. This alignment is showed by the ease and amount of information found in terms of curricular material, educational and recreational resources, as well as laboratory programs and curricula supported by government entities (Charters, 1992; Greenwald ML., 1978). On the contrary, when the teaching of the subject at the higher education level is analyzed, the modalities and/or types of programs are far from what is proposed by Kandpal and Broman in table 1, in such a way that the cases, investigations and material for the teaching decrease considerably. This is how Karabulut *et al.* (2011), do research on the teaching of renewable energies at the university level in Turkey, finding that education on topics

such as geothermal, solar, and wind energy are taught only at the postgraduate level, while other sources are taught at the undergraduate level within engineering program courses. However, this teaching is encyclopedic, since the preparation and obtaining of didactic material is expensive. In this sense, the importance of expanding and strengthening education in the different sources and technologies of renewable energy and energy efficiency at the higher education level is highlighted (Karabulut *et al.,* 2011), as well as educating not only in areas of specific work but also about creating awareness for people of all ages and interests to implement and share best practices and strategies to support the transformation of the global energy system, creating a future supplied by clean sources and the harmony of sustainable living (Middleton, 2018). Similar conclusions are reached by other authors such as (Dias *et al.,* 2021; Mulder, 2017).

It is important to highlight that the above applies in terms of face-to-face education, when the case is studied in remote education, the situation is more critical, and the cases of analysis are minor. Works such as Torres-Ramírez *et al*. (2014), who use as an educational tool the creation and dissemination of videos for the teaching of renewable energies, applied both in face-to-face and remote education, at the undergraduate and postgraduate levels; and Pastor *et al.* (2020), who shows the development, implementation, and integration of remote renewable energy laboratories in Jordan, presenting themselves as an essential resource to improve the quality of online teaching in engineering courses. However, the infrastructure and resources to develop this type of laboratory are remarkably high and require the participation of the government. For this reason, these cases are limited, especially in developing countries such as Colombia.

In this context, this research shows the challenges in teaching renewable energies in higher education in a digital world, strongly permeated by the situation left by the pandemic, as well as by the resources and policies of HEIs in Colombia.

4. Materials and method

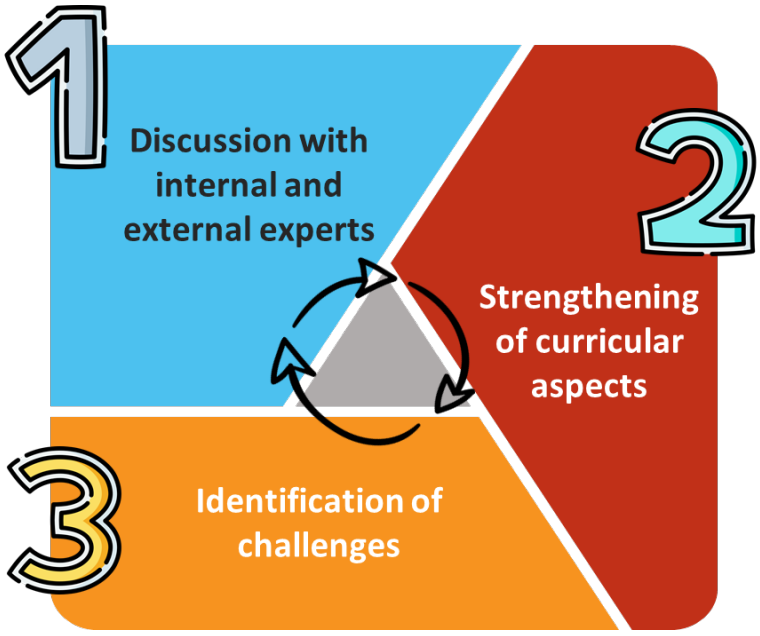
4.1. Research type and approach

The research approach is qualitative, found in a dynamic two-way reflection, between the facts and their interpretation, so that the tools and material used are adjusted in accordance with the results obtained and in coherence with the nature of the educational process itself, being as much effective as possible. Likewise, the evidence supplied is of a verbal symbolic type, in the form of images or audiovisual, reinforcing its qualitative nature (Hernández Sampieri *et al.,* 2014).

4.2. Methodological design

The methodological process was divided into three sequential and logical phases so that the results of one would be input for the development of the others, and thus make a correct construction of the process, according to figure 1.

Figure 1. Methodological design



Source: Authors, 2022.

Phase 1. Discussion with internal and external experts: in this phase, academic debates were generated through the formation of focus groups, to identify the basic elements to be considered in the structuring of the curriculum and the pedagogical strategies, and to update the knowledge of the "Renewable Energy" course.

Phase 2. Strengthening of curricular aspects: the contents of the course were strengthened, through the evaluation of the current curricular structure at that time and the development of a new curriculum that would integrate the results of phase 1.

Phase 3. Identification of the challenges in teaching renewable energies in a digital world: the results were implemented, and the challenges that were not considered from the beginning were identified. In this phase, these challenges are presented, as well as how they were addressed to overcome them, within the context of the earlier results.

4.3. Population

A population sample of 130 students was impacted, belonging to the research group "Grupo de Investigación en Desarrollo Sostenible Energético -GIDSE", as well as three different engineering programs (Industrial, Software, and Electronics), enrolled in three different campuses of the university, such as Bucaramanga, Valledupar, and Cucuta. In addition to the multiculturalism that this implies, it is noteworthy that the participating students were in all regions of the country in different academic semesters, making it necessary to have a broad and flexible curricular design. Similarly, the internal experts who took part in phase 1 were professors who guided the subject in the last 5 years, as well as the postgraduate directors at the masters and doctorate levels in renewable energy of the Institution. For their part, the external experts who took part in the debates are professionals with experience, who have carried out previous research and are active in academia.

5. Results and discussion

The results were structured considering the phases of the methodological design and the very goal of the study. In this sense, as a result of the discussion with the focus groups, four fundamental elements of a pedagogical, didactic, curricular, and evaluation types were found, which served as the basis for reflection on the teaching-learning process, in an attempt to change the current educational paradigm. Table 2 summarizes the main findings in each element, describing its historical approach.

Table 2. Historical approach to teaching renewable energies

Element	Description
Pedagogical	Face-to-face chair, with a duration of 80 semester hours, of which 48 correspond to work with teacher support and 32 to independent work.
Didactic	Simulation laboratory, which has a conveyor belt, and different Lego Education kits for teaching renewable energies.
Curriculum	-Course plan or syllabus of the subject, divided into 5 large sections: i) course information, which presents the student with the name, code, modality, and hourly intensity of the subject; ii) justification of the subject detailing the purpose of training, skills to be developed in the academic semester, as well as the performance criteria and evidence of these; iii) topics and subtopics, describing the units that are addressed in the course, which arise clearly from the technical and disciplinary content; iv) methodological and learning assessment strategies and v) educational resources and bibliography. -Class plan, which consists of a broader description of section three of the course plan or syllabus. This is divided into three large sections, as follows: i) course identification; ii) competencies; and iii) in-depth description of the topics, detailing performance criteria, evidence to be delivered, teaching-learning activities, time intensity, topics, subtopics, and educational resources.
Evaluation	Quizzes, class workshops, a partial for each period (three periods), reading and analysis of scientific articles.

Source: Authors, 2022.

According to the table, the historical approach to the teaching of renewable energies was clearly based on the disciplinary contents. When the construction of the documents that guided the subject is analyzed, there is no evidence of a structural base and tools that allow facing the challenges of teaching the subject in a digital world, and even less, the challenges of the pandemic.

These findings support the reflection on the new paradigm shift in the teaching of renewable energies, considering the digital world of university students, as well as the problems that permeate the teaching-learning process, even more so in times of exceptionality such as is the pandemic. This reflection process was guided by questions such as how to think about education on renewable energies considering the context of the students, as well as a transition from educational processes to digital platforms, where attendance is not a possible idea? What

digital pedagogical strategies would promote the successful participation of students, considering the limited technological tools of teachers and students? What are the advantages, disadvantages, and gaps in terms of technology and digital skills illiteracy, both of students and teachers, and how to respond assertively in accordance with limited resources? Which of the experiences of teachers can be adapted for a successful educational process, in a digital age?

This process of reflection, historical analysis, and rethinking of the teaching of renewable energies in a digital age integrating the current training scenarios forced by the pandemic led to a new consolidation of the pedagogical, didactic, curricular, and evaluation elements, as showed in Table 3.

Table 3. New paradigm for the teaching of renewable energy.

Element	Description
Pedagogical	Learning from constructivism. The joint construction of knowledge is prioritized, based on dialogue and argumentation to promote a dialogical attitude of students and teachers.
Didactic	Videos, lego education, hydrogen vehicle, online interactive simulations such as PhET Interactive Simulations from the University of Colorado at Boulder, Endesa Foundation, among others; interactive games like Wonder Ville: save the world, among others; and extended classrooms.
Curriculum	-Transformation of a syllabus for face-to-face learning to a syllabus for remote learning, with a division into five sections: i) course information; ii) justification, training route, and competencies; iii) learning, where strategies for the student in their independent work, levels of competence, evidence of learning and strategies for evaluating learning are detailed; iv) teaching, which covers thematic units, methodological strategies for teacher support, activities to strengthen global skills and generic skills; and v) educational resources and bibliography. -A new document called "Instructional Design" is generated, which replaces the lesson plan, divided into four sections: i) general design of the course; ii) topics to be developed; iii) thematic development, week in which it will be addressed, activity to be carried out by the teacher, responsibility, and activity to be developed by the student, duration, primary and complementary resources for learning; and iv) moments and modalities of feedback.
Evaluation	Project-based evaluation, which seeks to strengthen the topics covered in class through teamwork, healthy competition, identification and management of multiculturalism, self-management, and stimulation of the five senses, among others. Likewise, so that this evaluation process is complete and does not remain purely in qualification, the rubrics are created for each of the projects, easing the student's self-management.

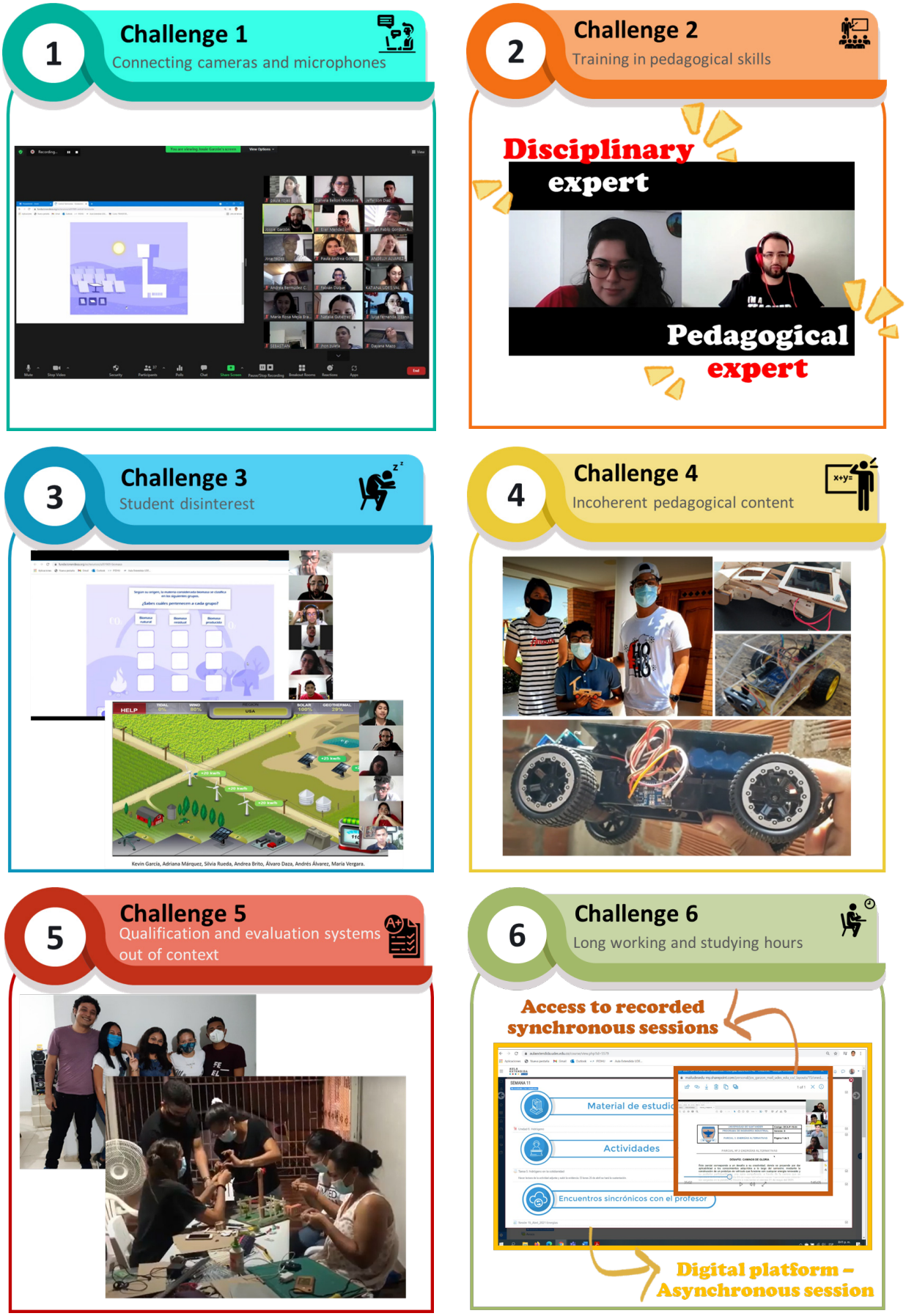
Source: Authors, 2022.

This new pedagogical and curricular design is established not only for the formation of the student's know-know and know-how but also fully considers the formation of the being, resuming creative exploration, independent and critical thinking, forming competent citizens capable of facing social challenges, and to project transformations, from an awareness of its role in the environment and its link with sustainable development. Likewise, digital tools that respond to the present and future challenges of students, in a digital age, are integrated with a clear sense of training.

Now, it is important to recognize the articulation between the intended, applied, and achieved curriculum, and its influence on the teaching-learning process. Although the design of the new paradigm for the teaching of renewable energies contemplates these elements, there is didactic planning that implies the organization of goals and activities that give meaning and continuity to the educational process, allowing to approach in a pertinent way the diverse situations with sense in the construction of knowledge (Torres & Gamboa, 2021). This is how, although the transition from face-to-face education to remote education can be thought out and structured very well from theory, the improvised response of the Ministries of Education and HEIs, and the forced acceleration of the process for teachers, generated new challenges throughout the various stages of educational reorganization as a result of the pandemic.

This research exercise made it possible to show the most representative challenges of this first stage, as well as the way in which they were addressed and overcome, as shown in figure 2.

Figure 2. Challenges in teaching renewable energies in a digital world



Source: Authors, 2022.

The first challenge is based on the difficulty for students to turn on their cameras and microphones, affecting the teaching-learning process and feedback in the construction of the class. The selected pedagogical model allows students to identify their real roles, involving them at all times. Likewise, the didactic material allows the structuring of recreational activities, where students must debate among themselves and generate a single answer to the questions posed, prompting them to connect their cameras and microphones to reach points of agreement with their classmates.

The second challenge is the lack of training in pedagogical skills by teachers. In order to address this challenge, a dual teaching model was proposed, where one of the teachers is an expert in pedagogical skills and the other in disciplinary skills. The implementation results show a more effective teaching process, which the students highlighted throughout the class, as well as in the evaluation processes.

For the third challenge, the accelerated and improvised transition from face-to-face education to remote education caused a high degree of disinterest in the students towards their training process. This was clear not only in the difficulty in getting them to participate in class, but also in times when they did not get out of bed, or it was heard that they were in other activities. To address this challenge, the appropriate design of the pedagogical, didactic, curricular, and evaluative elements was used, leading to the fact that, as the number of remote classes increased, the students began to turn on their cameras by their own decision, locate themselves in adequate spaces for the process and be an active part of it, awakening and maintaining their interest.

The fourth challenge represents incoherent pedagogical content, which was taught in a way that was decontextualized from the student's reality. The update of the syllabus allowed adjusting the pedagogical contents of the subject, and the purposes of the training process. This update considered learning for a digital age, in accordance with the contingency of the pandemic. An example is presented, where the application of renewable energies in the transport sector was sought, through an activity that promotes healthy competition, by designing a vehicle powered by renewable energies, and putting it in competition with its peers, remotely.

The fifth challenge identifies the decontextualization of the evaluation and qualification processes, compared to the student digital environment. The evaluation by projects and the correct design of the rubrics allowed the development of self-management skills, where the students executed a hybrid methodology by their own decision, taking advantage of the fact that they were in common regions to meet in person, considering biosecurity measures. This, in addition to promoting collaborative learning, also creates spaces that are conducive to the development of soft skills and self-training skills.

For the last and sixth challenge, the pandemic meant that the line that divides the personal, family, and professional life was blurred, therefore, a student can connect to class from work, but focus their attention on what most demands their time at that specific moment. Although this is a larger social problem, the new pedagogical conception of the teaching of renewable energies allowed that, through short synchronous sessions, the student could interact with his classmates and professors; and that likewise, through digital platforms (extended classrooms), they could asynchronously access study material, recordings of class sessions and assigned activities.

It is important to note that not all the challenges can be assumed by teachers from their classrooms or remote sessions. However, it is highlighted that the new paradigm of teaching has led to a new definition of the role of the teacher, going from being the sole possessor of knowledge, to becoming a facilitator of the learning process (Delors, 1996), by promoting and support for independent work, implementation of flipped classrooms and active methodologies that guarantee the learning process (Chibás-Ortíz *et al.,* 2014; Diego Mantecón *et al.,* 2021; Steinbeck, 2011). This is how this research, in addition to identifying the most important challenges and their approach, also identifies other challenges of a social, cultural, and political nature, for which the intervention of the State is required, with transversal and duly thought-out policies.

Among these challenges, the following stand out: i) poor access to energy or excessive intermittence in the electrical service, which makes the teaching-learning process impossible, ii) non-existence of well-being in the home, iii) lack of technological equipment and digital infrastructure such as the internet bandwidth, iv) environments not adapted for teaching-learning processes, v) anxiety, depression, psychological pressure, and vi) illiteracy in digital skills.

6. Conclusions

As showed, the challenges identified are not limited to the teaching of renewable energies but are transversal to any subject that wants to be taught. The vast majority of these correspond to social problems, which were accentuated by the pandemic. Similarly, for unlicensed professionals, it is difficult to face pedagogical challenges, given their insufficient knowledge of education. On the other hand, the transition from face-to-face to remote education accentuates this problem, urgently requiring the assumption of previously unimaginable challenges for the educational policy of all countries, not only due to the global contingency of the pandemic, but since, from an analogous perspective, the real and transcendent pandemic is the myopia of those who lead educational policies, ministries of education and educational institutions. This myopia has not allowed the real end of education, which has accepted that the market is the one that defines educational practices, and with this, it builds values and the

social environment, transcending all human spheres, including environmental aspects. On the other hand, the implementation of this new educational paradigm requires a process of continuous improvement, considering the reality of students and the country, which makes certain challenges more acute than others. This is how, when working under multicultural criteria, it is necessary to prioritize certain challenges.

In reference to challenges 1 and 3, it is evident that this same criterion of multiculturalism and the characteristics of each region have an impact on class participation, so that the personality of those who belong to coastal areas of the country is more extroverted and therefore they are more open to contributing to the class; while for those students from the interior of the country, the most effective strategy to achieve the same goal corresponds to the use of didactic material and recreational activities. Likewise, facing challenge 4, it is important to highlight that the second academic semester allowed the strengthening of interdisciplinary work, by linking software, industrial, and electronic engineering students, thus increasing the quality of the projects presented compared to the first semester.

On the other hand, in the second academic semester, the country presented complicated situations of public order, caused by the national strike, which led to prioritizing challenges 5 and 6, thus making the evaluation process more flexible and strengthening the asynchronous elements, in the to the extent that a large part of the student youth population took part in said marches. This is how having extended classrooms, class recordings, and a well-structured remote-digital environment eased and improved the teaching-learning process.

Finally, the interaction of the professors transcended the class to different research projects, and to the leadership of a research group of the program. The foregoing allowed the pedagogical expert to strengthen his knowledge in the disciplinary aspects and, therefore, the disciplinary expert to strengthen his knowledge in the pedagogical, didactic, curricular, and evaluative competencies, achieving teacher development and improvement of the work through this interrelation. This stands for a simple exercise to overcome one of the most important challenges in education, corresponding to teacher training.

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