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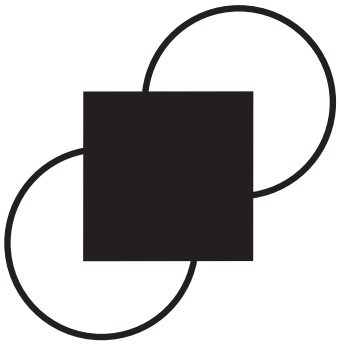

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ACTIVE LEARNING STRATEGIES FOR HEI SUSTAINABILITY: A CHARACTERIZATION

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Abstract

Higher Education has been assuming several challenges in the last decades. The increase in the number of students, the evolution of technology, globalization, budget restrictions, among others, have been influencing how Higher Education Institutions fulfil their mission. To cope with these challenges, Higher Education Institutions should be sustainable, to be able to keep high educational standards, research and development and resource consumption. Adequate, active, learning strategies have the potential to contribute to the teaching-learning process sustainability, developing the sense of responsibility, the need to respect and be respected, the effort to discuss and get to the best collective decision and the development of the students' agency. Based on a systematic literature review, this paper characterizes the resulting papers in terms of provenance, evolution throughout the years and area. It is clear that there is a trend in the topic, although there is also a set of challenges that delays the wider adoption of active methodologies. Sustainability is a concern that is seldom explicitly mentioned, although the authors reveal that using active technologies contribute to organize the students' study time and their attitude regarding their role in the learning process.

Keywords: teaching-learning, sustainability, higher education, literature review.

1 INTRODUCTION

Higher Education Institutions (HEI) have the mission to train, at high level, the population, so that students can become productive professionals as well as participative and social-aware citizens. Although the mission did not change for several decades, democratization of higher education, technological advances, and globalization has been presenting a set of demanding and important challenges. Higher education is welcoming more students, with different social-economic background, cultures, motivation and autonomy. In addition, despite the increase in the number of students, the budget restrictions and infrastructural constraints, further complicate the ability for HEI to fulfil their mission. Education institutions need to implement sustainability strategies, encouraging optimum utilization of resources to be able to cope with these scenarios [1].

Sustainability, in this context, pose multidimensional challenges. Students are required to assume an active role in the construction of their knowledge, with high levels of motivation and commitment. Teachers are required to help students to develop their knowledge with increasing complexity and social and economic relevance, and, at the same time, contribute to the Research and Development (R&D) advances. Institutions are required to operate without unnecessary spending on energy, infrastructures and personal. These require adequate pedagogical strategies, the establishment of communities of practice and research centres, and the optimal resource management, cohesively articulated under sustainable leadership policies [2].

This paper focuses mainly on the characterization of effort of HEI to adopt active pedagogical approaches, in the context of their potential contribution for stimulating student autonomy. The data is collected through a systematic search in the main scientific indexes, and result from the analysis of the content of the papers retrieved.

1.1 Challenges in Higher Education

There are several factors that have contributed to the organizational, scientific and pedagogical changes in Higher Education Institutions (HEI). Globalization has been one of the biggest influencers, since the underlying interconnectivity between HEI and societal challenges has accelerated economic, cultural and social changes. This assumption highlights the importance of HEI on the promotion of high-quality critical thinking, training professionals with complex scientific and practical knowledge that

allow them to act in the volatile labor market, as well as to contribute to the development of scientific research, further enable economic grow and social innovation.

Evidence linking the development of the economy, health and social empowerment to HEI has led, in the last fifty years, to the massification of higher education, which also contributed to substantial changes in their organizational system [4], [5]. This phenomenon is also related to the democratization of education and the promotion of social justice that have incorporated the goals of many countries in the recent decades [6]. This situation has encouraged the entrance of new groups of students in higher education, with reflection on cultural diversity, the variety of aspirations and expectations. The internationalization of HEI, supported by European policies, have strong impacts on mobility of students and teachers. It is also an enhancer factor of change in organizational dynamics. The OECD envisaged that mobility would increase by bringing student audiences from outside of Europe, particularly from Asia and India [7]. Ten years later, the demand for European Universities by student from African and Latin American countries shows a new trend.

Technological development has contributed to the appearance and modification of many professions, highlighting the importance of developing skills in line with the needs of the labor market. According to the World Economic Forum, it is estimated that 65% of children attending primary school today will work and perform professional activities that do not yet exist [8].

In order to deal with the volatility, uncertainty, complexity and ambiguity that contemporary societies face, the following ten core competencies have been identified and hierarchized: complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision, service orientation, negotiating, and cognitive flexibility. This reality challenges HEI to foster educational quality, to rethink the curricula, to create adequate learning environments, and to promote teaching and learning experiences that stimulate the development of students' transversal skills. Considering the current scenario, teaching is no longer a simple function of transmitting knowledge, but a complex profession.

1.2 Teaching as a complex profession

Teaching as a process that favors the meaningful learning of students, is a complex process that requires a constant reflection and research, the knowledge of teaching-learning methodologies capable of promoting experiences that allow the students to solve complex problems, think critically, work with the others, develop scientific and technical skills, fundamental for their future life and the profession.

The criticism to the technical rationality, assumed in the traditional HE teaching methodology, and the emergence of the critical-reflexive perspective allows recognizing the importance of the teacher in higher education and his professional development [9]. However, the conceptual diversity seems to make professional development the main challenge in higher education pedagogy.

According to Hargreaves and Fullan, from the conceptualization of the professional development, different perspectives emerge, resulting from different understandings regarding the teaching and learning opportunities [10]. To them, the concept of professional development follows three paths. The psychological development of teachers, that refer to their personal development and that requires work about themselves, about their representations, their behaviors and their actions. This perspective values the teacher-person, that use thought and emotion to answer to complex, day-to-day, circumstances. Another perspective is focused on the professional development of the teacher, to develop knowledge and skills, teacher strategies and techniques and the full understanding of the content. A third approach defines the professional development in the relation with the context, as a daily process, from an action-research approach.

In the current social-economical context, the teaching-learning challenges are guided by both the society requirements and the teacher development process. In addition, HEI consider that sustainability, among other factors, is also associated with teaching and learning quality. Effective change is typically driven by a combination of top-down and bottom-up initiatives that changes and evolves over time. Institution leaders "seek to change the culture of the institution through centralized steering and, on the other hand, teachers assume a professional development culture that reflects the discipline-specific features of academia" [9, p. 25].

The literature reflects these two directions. Initiatives that originate in the class, and others of the responsibility of institutions. For the success and sustainability of the change, it is fundamental that adequate articulation, joint reflection and leadership support.

1.3 Teaching and learning methodologies

Teaching and learning quality, beyond teacher and leadership involvement, requires the knowledge of active pedagogical methodologies and the context dimensions that value the development of knowledge. There are several methodologies mentioned in the literature to support students to develop technical and scientific skills, as well as transversal competences, that we group in the following main categories: collaborative learning, experiential-based learning, participatory action research, game-based learning, storytelling.

However, pedagogical innovation has been demanding the use of Information and Communication Technology (ICT) tools to support teaching-learning methodologies. These assume an important role in the assurance of the democratization of learning, providing access anytime, anywhere, to differentiated groups of students. Many papers in this literature review refer the use of ICT tools and techniques as methodologies, although they are, in fact, supporting tools instead. Some examples include blended-learning, gamification, MOOC, flipped-class, Web 2.0 supported pedagogies, virtual and personal learning environments, crowd learning, wiki, among others.

Related to pedagogy in higher education, the literature highlights the assessment as a mean to foster learning, assisting students to learn and certifying their outcomes. Some assessment approaches or techniques contribute to involve the students' in the process of awareness on their achievements. On the other hand, assessment is also used to grade students through the definition of marks. The latter, obeys the institutions' regulations, providing a summative assessment or ranking. Formative assessment, on the other hand, provides constant feedback which allows on-going process of development.

Active methodologies require the students to assume a fundamental role in their learning process. To ensure their participation or their effective involvement, the learning experiences should be designed for the students and with the students. For them, because teachers should consider the specificities of the different groups of students and also their individual particularities. With them, to assume their expectations and considerations in the experiential on-going process.

Based on these assumptions, this paper led us to explore, through a systematic search in the scientific literature, what are the emerging trends on the use of active learning methodologies in higher education.

2 METHODOLOGY

The main objective this work is to identify active pedagogical methodologies mentioned in scientific papers and to categorize their use in higher education. The systematic search methodology follows the approach suggested by Materla, Cudney and Antony [11] and by Subhash and Cudney [12], which includes three phases: planning, operational and reporting and dissemination (Figure 1).

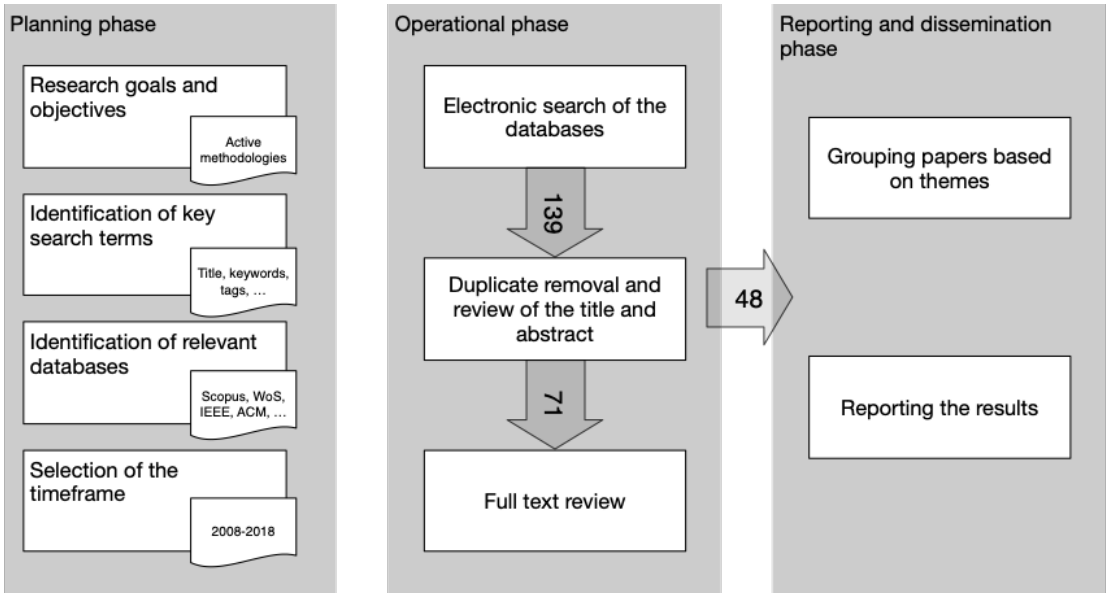

Figure 1. Systematic review methodology.

The papers were searched in Scopus, Web of Science, IEEExplore, ACM Digital Library, and Google Scholar. The search term was defined as “Higher Education” AND “Active” AND (“methodologies” OR “strategies”). It was applied in the title of the paper and, in Scopus and IEEExplore, also on the keywords.

These databases were selected as they comprehensively cover the broad base of application areas and the search term provides a concrete initial focus on the objective of this literature review. A total of 139 papers were identified in the first search (Table 1).

Table 1. Search terms and number of results returned.

Database	*Search term*	*Results*
Scopus	(TITLE ("higher education" AND active AND (methodologies OR strategies)) OR KEY("higher education" AND active AND (methodologies OR strategies)))	49
Web of Science	TITLE: ("higher education" AND active AND (methodologies OR strategies))	8
IEEExplore	(("Document Title":"higher education" AND active AND (methodologies OR strategies)) OR "Index Terms":"higher education" AND active AND (methodologies OR strategies))	44
ACM Digital Library	“title” “matches all” “active higher education”	6
Google Scholar	allintitle: active methodologies OR strategies "higher education"	32
	Total	139

Only papers found in the databases through the authors' institutional library and published since January 1, 2008 until December 31, 2018 where considered. Grey literature, repeated search results, and papers that did not contain full text in English were excluded. After eliminating repeated papers, the total number of results was 117 references. Of these, only 77 had the PDF file available and, after eliminating papers published before 2008, a total of 71 remained. A detailed review of the title and abstract of the remaining papers was conducted, followed by a thorough analysis of the whole text to eliminate those that did not meet the inclusion criteria for this study/systematic review. A final 48 papers remained after this step. The guidelines for the full text analysis aimed at identifying active pedagogical methodologies, mentioning by name each of the methodologies and provide a short description of according to the authors. Next, keep in mind their use in higher education and look for the benefits, how they were identified (evaluation methodology) and factors for successful implementation.

3 CHARACTERIZATION

In total, papers from 15 countries were found (Figure 2). Spain is remarkably present, with over 50% of the total number of papers published (26), followed by the USA (6), Portugal (3) and China (2).

The distribution by year reveal a peak number of papers around 2010-2011 followed by a slight decay (Figure 3). In 2012 there was no paper selected and 2016 a single paper was analysed.

There is a higher concentration of papers in the engineering area, including electrotechnical and telecommunications engineering, computer science and industrial engineering (Figure 4). Related to these, follows mathematics and statistics. The generic designation is used to represent active learning activities that can be used, potentially, in any area or course. In these situations, the authors describe the methodology, their benefits and usually point that they can be used in any subject.

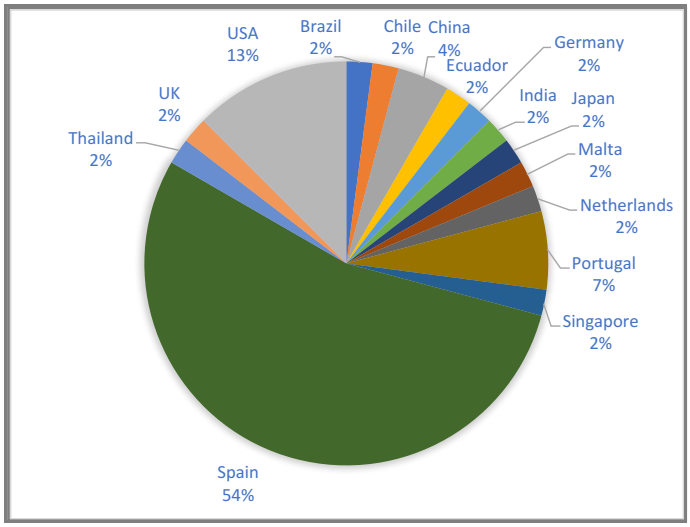

Figure 2. Paper distribution by country.

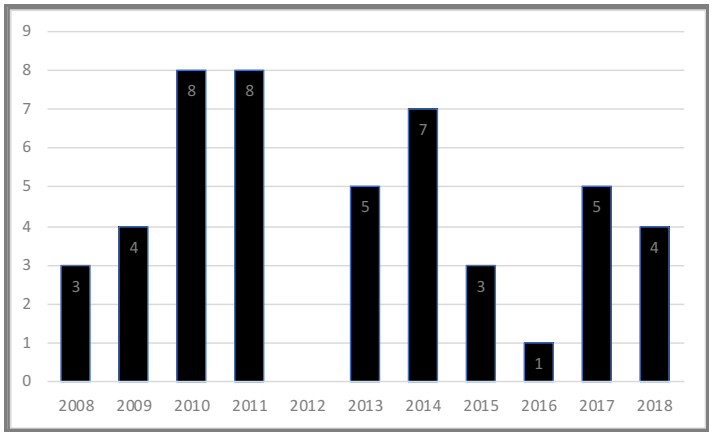

Figure 3. Paper distribution by year.

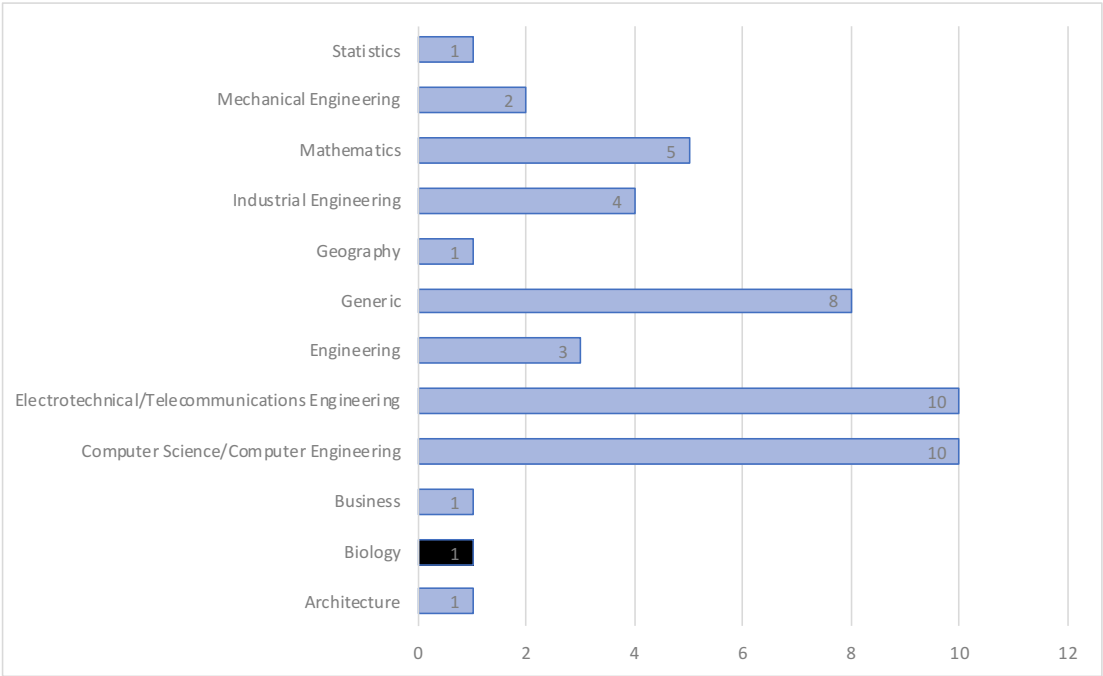

Figure 4. Paper distribution by area.

Understanding the impact of active learning methodologies in HEI sustainability raises a few challenges, due to the diversity of methodologies, techniques and resources. Based on this, and according to the theoretical context described above, four top-level categories emerge, related to how students learn (learning strategies), how to assess their learning (assessment), where do they learn (classroom, self-study, ICT) and what they learn (learning outcomes). The papers were grouped according to these categories. Some papers refer only one of the categories, although other mays refer to two or more.

Collaborative learning: the learning process can benefit from the interaction with the colleagues. This interaction can result from competition, in which students strive to overcome the colleague opponent, or collaboration. To prevent duelling between collaboration and cooperation concepts, we consider, in this study collaborative learning as un umbrella concept, that groups competition, collaboration and cooperation. Arribillaga uses a wiki to stimulate the participation of students as knowledge generators and to allow the university to transmit values and content [13]. Regueras, Verdú, Muñoz, Pérez and Castro use the concept of a QUEST, a module developed for the Moodle platform, that associates competition with collaboration [14]. For large classes, the collaborative learning can also be used, for example through a Clicker [15]. In this experience, students are grouped in teams, where each team holds a Clicker. This device allows students to react to the questions presented by the teacher with immediate feedback regarding their option and the option of other groups. In addition, this strategy is complemented with group presentation and peer-assessment, further committing students to the responsibility of the learning process. Carpeno, Arriaga, Corredor and Hernandez use different group dynamics to motivate students to reflect, discuss, present and organize the content presented by the teacher [16]. Group formation is important and influences the student's commitment and involvement, as well as the democratic access to learning [17]. In this context, Liu, Li and Du describe an automated system that, based on the students' profile, can manage and recommend grouping formation strategy, task generation strategy and collaborative control strategy [18]. Domínguez and Magdaleno use a random approach to form groups, distributing to them a guide containing practical information on what has to be done and how it should be done [19]. In addition, they also use other strategies, such as a QUESTOURnament, a Moodle module to organize individual and group contests. Martín, Urpí, Casany, Burgués, Quer, Rodríguez and Abelló use several techniques for collaboration, such as individual writing and problem solving with posterior group discussion and correction (Write-Pair-Share, Send-A-Problem) and group solving (Structured-Problem-Solving) [20]. They also found that this methodology contributed for students to have higher grades. The purpose of Rajaram is to achieve an holistic environment for learning, that helps students develop knowledge in several dimensions, including academic knowledge, transversal skills, through a variety of pedagogical strategies that value learning from failures, out-of-the-norm thinking, asking questions and respecting all opinions [21]. Romero-Ternero stimulates collaboration among students through two strategies [22]. Role-play, that allow students to adopt a role that encourages them to think, to act and to make decisions as their characters would, and jigsaw, which consists of dividing the material in independent parts and assigning each part to a member of a team. Role-play is also used by Gohokar and Dhend, further complemented with debate, to stimulate the oral and written communication, problem solving, applying the knowledge for particular applications and analysing, comparing the strength and weakness among the group, and a quiz, in the form of a treasure hunt competition [23]. Finally, Valentim, Carvalho and Barreto, in order to stimulate digital competences and collaborative work, apply the SCRUM methodology, traditionally used for software development, in educational environment [24]. Although they perceived improvements in personal and team organization, the adoption of a workplace methodology for class environment has some difficulties that emerge from the differences in schedule and technological limitations, such as intermittent connection to the internet.

Active learning stimulates the student to critically think about what he is learning or what he is doing. This experience is analysed, by reflection, evaluation and reconstruction in order to draw meaning from it in the light of previous experience. This is the distinguishing feature of experience-based learning, which may comprise earlier events in the life of the learner, current life events, or those arising from the learner's participation in learning activities [25]. By definition, this is a broad term, that includes all forms of experience. In this paper, we use the term to encompass the project-based learning and problem-based learning methodologies, since they imply learning by experiencing specific learning activities.

De Graaff researched and reflected on an example of implementation of a problem-based learning methodology that, not long after, failed [26]. They refer that adequate leadership and connection to the companies are fundamental to implement a successful experience. In this context, López-Salcedo and Seco-Granados decided to adapt a conventional subject to include 25% component based on

Problem-Based Learning [27]. It included role-play, so that students could prepare and simulate the standardization process of technology and present and discuss it with a board of standardization, of the instructors' responsibility. This way, students would be able to develop not only specific competences but also some communication skills. They would realize that no unique or optimal solution can often be found in practice. Moreover, when discussing with the committee, the groups should also learn to defend their option. Ponsa, Amante, Roman, Oliver, Díaz and Vives present an structure and organization to implement Project-Based Learning and Problem-Based Learning transversally through a set of subjects in a degree in Industrial Engineering [28]. This would lead to multi-disciplinary projects supported by several teachers of several courses. They introduced the role of the Project Coordinator, responsible for designing an overall interdisciplinary plan for the projects to be carried out by the student. Since the problems and projects cover several courses, co-ordination between these subjects requires an area coordinator, the Head of the Centre's Teaching Plan. Finally, there is also the Tutor, the figure who is closest to the students and guides and helps them in their academic progress through the curricula. Lantada, Morgado and Sanz assume a process for toy design and manufacture as a project for the course in Design and Manufacture with Plastic Materials, of the degree in Mechanical Engineering [29]. The project was initially defined and, then, four phases are followed: i) approaching the problem, which allows the students to gather information on their products and analyse existing solutions together; ii) conceptual design using CAD tools; iii) detailed design, and, finally, iv) prototype manufacture, where the toy was produced using rapid prototyping technologies. After that, students make their final results public, and justify their decisions to their teachers and colleagues. The joint discussion on the different tasks performed allows each team to learn from the work of their peers. Garcia and Hernandez assumed the Problem-Based Learning methodology by the initial definition of problems that should be solved by the students through the semester [30]. Teachers expected that the students would study the concepts, relate the different theoretical aspects and understand how to select and use the different tools needed to solve the problem. The activities would encourage students to follow the course on a daily basis and would result in better understanding of the concepts and higher marks. A similar approach was followed by Pérez, Garcia and López [31]. Teachers define the project to be developed by students during the semester. In addition, a tutor is appointed to closely follow the development of the project, to better clear the tasks that need to be completed. Varela, Bilbao, García, Rodríguez and Bravo specify four problems students should solve [32]. Students are able to get better results with the suggested methodology. Oleagordia, Barrón, Martín and Asensio propose assigning the design, development and assembly of a battery charger prototype aimed at optimizing the performance of photovoltaic solar panels [33]. They support the project development in groups of students, to foster also collaborative learning. They guide the development of the project with theoretical study and discussion followed by laboratory activities and documentation development. Oliveira and Oliveira also specify and integrator project, called physics elevator project (PEP) that is designed to use all the content taught in an Introductory Physics course [34]. They rely on several active learning strategies, such as group work and problem solving, with a final written report describing the students' options and results.

Game-based learning benefits from the educational potential of games. The introduction of games in the classroom has, thus, the possibility to replicate the motivational and engagement effects of games to develop skills, encourage positive competition and promote the development of collaborative processes among students. The implementation of a successful initiative in education is challenging, requiring the right balance between what can be considered fun and what should be the learning effects of the experience. A game-based learning experience should not be strictly ludic. It should be designed with an educational purpose in mind, to help student develop transversal competences, knowledge or to provide simulation environment. The literature is not very rich in this subject. In this study we opted for not considering quizzes and challenges as game-based learning. We also not considered gamification as game-based learning, described later in this paper.

A single experience was reported, using the game "At Play in the Cosmos" [35]. It is an online game designed to teach undergraduate non-science majors about astronomy. It was created with the collaborative support of multiple content experts in astrophysics and a specialized team of artists. Each space mission introduces players to new astronomy instruments and scientific concepts, taking roughly 5-10 minutes to complete.

The storytelling strategy is based on the narration of a tale from memory. It involves selection and delivery, requiring choosing adequate stories and be a good performer. In educational context, it has the potential of fostering emotional intelligence, promote communication skills and reasoning. In this study we consider both written and oral experiences that allowed students to freely express themselves as well as the teacher as a storyteller to motivate the students' knowledge development.

Regarding the later, Alberts uses the description cycle of cacao production and processing to stimulate the learning of several related aspects, such as cultural geography (regional food preferences), fair trade in the economic geography, political geography (the European Union) and social/political geography (human rights) [36].

The last strategy identified in this study was participatory action research. This approach allows defining, by negotiation, a research subject with a complete research methodology, in close articulation with the community. Elwood uses this strategy for Geographical Information System (GIS) learning, in articulation with the Humboldt Park Community [37]. University students, community members and local residents created an updated version of a neighbourhood strategic plan and developed spatial data for GIS applications. In this, individuals and communities are situated as researchers, rather than research subjects. They are involved in identifying research needs, formulating research questions and methods, carrying out research and applying results. The learning experience has, thus, direct impact on the community and on the students.

The collaborative learning, experience-based learning, game-based learning and participatory action research strategies were used, by several authors, as active pedagogical strategies in higher education. According to regulation, students have, however, to be assessed, so that a mark can be defined. The authors also considered this issue, integrating the summative and formative assessment with the active learning strategy.

4 CONCLUSIONS

Considering the evidence emerging from this work, HEI and teachers face a number of challenges for the future. It will be important that teachers have effective pedagogical skills for helping students to achieve the expected learning outcomes, and it is also necessary that organizations provide means to support teachers' efforts.

Teachers should also prevent focusing the professional learning process in themselves, as individual learners. They need to co-operate with students, colleagues from other departments, and with external stakeholders, as members of a dynamic learning community. The learning projects should not be provided by the teacher, but they should arise from the interests and needs of students and the community members.

Teachers should create learning environments that integrate teaching and research more intensively. Students should be involved in the research process as creators, so they could learn effectively about the research methodology and the evidences that emerge from it. Regarding this, it is necessary that teachers re-think the student participation in the learning process.

The contribute of the pedagogical methodologies for the sustainability of HEI has to be carefully planned, in articulation with all the actors, and that can contribute to reimagine the organization as a whole.

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