ACTIVE LEARNING METHODOLOGIES AT THE UNIVERSITY CLASSROOM

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Abstract

This paper identifies a set of active learning methodologies, which have in common the consideration of the emotion as a key element for learning. Active learning methodologies are not only intended to awaken emotions but also taught with emotion. To this extent, different teaching methodologies are used that complement each other, leading to reinforce and consolidate learning. Accordingly, the main aim of this work is to review the different active learning methodologies that can be applied at the university classroom, including: (i) flipped teaching; (ii) game-based learning; (iii) gamification; (iv) project-based learning; (v) role-playing games; and (vi) process simulation.

Keywords: active learning methodology, emotion, industrial management, university.

1 INTRODUCTION

Currently we are living a global industry change in which the job characteristics and requirements are changing. The evolution of industrial scenarios must be accompanied with the evolution of educational institutions, as well as the way they teach their courses. A new way of teaching must be incorporated in the universities, especially because they are the institutions in which the students learn the concepts to be applied in the new jobs that are appearing due to the industrial evolution, which is currently immersed in the Industry 5.0 [1][2]. The new era of jobs is mostly based to support the enterprises digital transition. Just a decade ago we were not so familiar with terms like big data, artificial intelligence, blockchain or cloud computing. And it is that the world of technology is in constant evolution and transformation, which favors the demand for specialized professionals in this field. The jobs of the future are characterized by being more digital and more changing. Rapid technological advances require professional profiles capable of adapting to new situations with great versatility. These profiles will be the protagonists of the jobs of the future.

Therefore, novel teaching paradigms have to flourish amongst the universities. In this regard, active learning methodologies are seen as an effective means to achieve expected employers' and educational demands. The change must be seen from the traditional learning-teaching methodologies to the active ones.

Traditional learning methodologies are centered on the teacher, while students are only passive listeners. Nevertheless, active learning-teaching methodologies are focused on the student whilst the teacher is the supervisor, guiding the activities around the active learning. The role of the teacher is transferred to the student that acts in an active way.

A wide spectrum of definitions and educational practices are associated with the term active learning [3]: learning from experience, discovery learning, learning by doing, inquiry learning, service-learning, peer tutoring, laboratory work, role-playing, case studies, problem or project learning, simulations, games, debates, essays, research, interactive use of all kinds of technological devices, information searches and synthesis, etc.

As Martinez et al. [4] states, active learning methods are introduced in classrooms to increase students' problem-solving and critical-thinking capabilities. Accordingly, the implementation of active methodologies in the courses subjects require [5]:

- Time for planning and performing practical activities
- The reduction of students per class, in order to increase students' personalization to meet their needs
- Appropriate environments for promoting active learning activities
- Materials and resources

- Technologies to deal with learning practices
- Appropriate planification and evaluation methods, because exams that require memorization are old approaches to evaluate
- Institutional support
- Training teachers to apply active methodologies of teaching in their subjects

These challenging requirements need to boost the implementation of projects for teaching innovation.

The Universitat Politècnica de València (UPV) has been promoting educational innovation since 1986, through successive programmes that have evolved over time and have managed to install a culture of innovation in our university, that is, a process of permanent reflection and improvement of its teachings to adapt them to the many challenges to which we must respond.

In the 2018-19 academic year, a process of integration of different institutional initiatives has begun with the aim of seeking synergies between all the institutional actions that, in relation to the improvement of the teaching-learning process, are currently being carried out or may be carried out in the future. This joint educational innovation plan is now called "Learning and Teaching" (A+D). In this call, the "Reverse Teaching" line is integrated into the "Educational Innovation and Improvement Projects", together with the calls for "Educational Innovation and Quality Teams" and for "Good Teaching Practices".

In short, all these actions are intended to continue to deepen and significantly improve the innovation proposals that are carried out at the UPV. The main aim is to reflect the latest advances in methodologies that promote active and constructive learning, as well as in learning assessment systems, all at a time when adaptation to different learning environments has become particularly relevant. But without forgetting that the ultimate goal is to train people, promoting the development of their skills with quality training oriented to the changing needs of society.

As part of actions to reflect latest advances in active learning methodologies and constructive learning assessment this paper focuses on an initial state of the art regarding active learning methodologies.

2 ACTIVE LEARNING METHODOLOGIES

Active learning methodologies are not only intended to awaken emotions but also taught with emotion. To this extent, different teaching methodologies are used that complement each other, leading to reinforce and consolidate learning. In this section, we review different active learning methodologies that can be applied at the university classroom (see figure 1), including: (i) flipped teaching; (ii) game-based learning; (iii) gamification; (iv) project-based learning; (v) role-playing games; and (vi) process simulation.

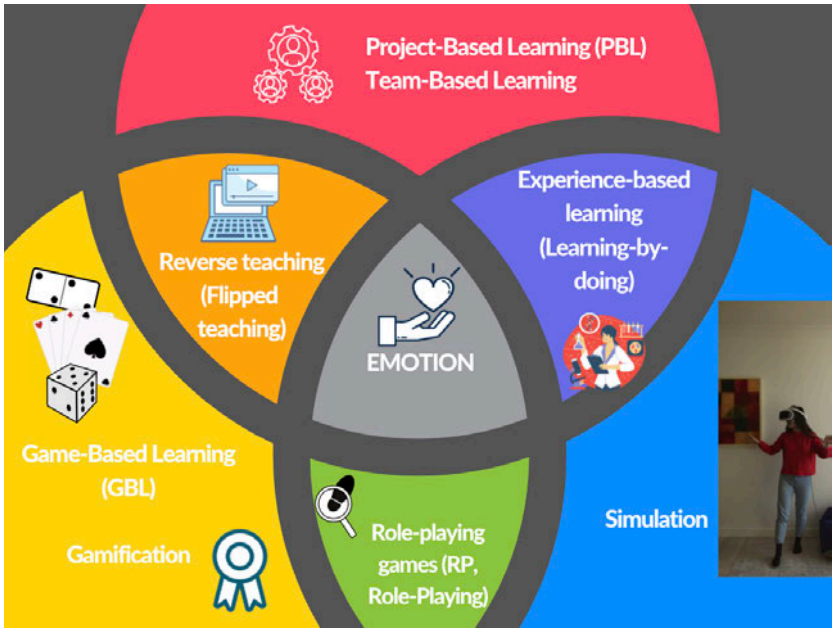

Figure 1. Active learning methodologies

2.1 Reverse teaching

Reverse teaching, also known as flipped teaching or flipped learning, is a student-centred methodology that emerged to increase the quality of learning during class time [6]. It consists of students working autonomously on the simpler or more concrete learning results (usually at home), while the more complex and cognitively higher-level learning results are worked on with the support and guidance of the teacher (usually in class).

The idea is that, instead of introducing concepts during class time, the teacher creates content, usually multimedia, so that students can work autonomously on this concept prior to the class. At this stage, it is not enough for students to visualise the content, but it is advisable to include formative activities and assessment [7]. Later in the class, more complex content related to what the students have learnt at home is worked on, or activities are carried out where the concepts are applied, or the opportunity is taken m. Usually, the activities to be carried out in class should have an added value, being not possible to do them independently at home. After finishing the class, students could carry out autonomous activities at home to reflect on and internalize the learning objects learnt.

Reverse teaching has as some of its advantages its positive impact on learner outcomes (improves learning performance, satisfaction, engagement, motivation, increases knowledge, improves critical thinking skills, feeling more confident, promotes creativity, among others), pedagogical contributions (flexible learning, enables individualized learning, enhances enjoyment, better preparation before class, fosters autonomy, offers collaboration opportunities, enables more feedback, among others), time efficiency (more efficient class time, more time for practice), dispositions (positive feedback from students, positive perceptions from students and teachers, and positive attitudes), or interactions (students-instructor, general, students-students) [8].

2.2 Game-Based Learning (GBL)

It is an educational methodology consisting of using games and/or video games in the classroom to learn content and skills, as well as their evaluation by teachers. Alkhafaf (2010) [9] defined this methodology as games based on specific plans, programs, tools, and supplies, designed as a guidance so the students can achieve specific objectives. Its main feature consists of making use of a safe environment to experiment and explore different decisions and actions while engaging the students with competitive and entertainment-related elements. This results in an emotional involvement rather than the impersonal approach that other classical learning techniques use [10].

Game-based activities must be designed so that they can motivate and involve the students in the game. According to Laine and Lindberg (2020) [11], challenge, competitiveness, achievements and objectives, control, feedback, and creativity must be basic principles in the development of any educational game. Plass et al. (2015) [12] point out the key supportive arguments for implementing game-based activities in class: i) the motivating effect of incentives and game mechanics; ii) the player's engagement; iii) the possibility of regulating the game according to students' needs (in terms of feedback and learning difficulties) and desires (i.e. personal interests or reduction in learning time); and iv) thanks to digital games safe environments can be created in which making mistakes and failure are possible, alleviating the negative consequences of failing while boosting the motivational possibilities.

Among the main advantages of implementing this methodology, the following stand out: enhances learning languages process (i.e. listening, writing, and reading skills) [13] ;leads to benefits for attentional and visual perceptual processes [14]; helps developing creative and non-standard problem-solving strategies [15]; have a positive effect on self-regulation and control of emotions [16]; and useful for learning of transversal skills related to collaborative work or creativity, complex thinking, information and technology [17].

2.3 Gamification

It is an educational methodology that is based on using game elements (in a non-playful environment) to design learning experiences that could take place without enjoying the playful component, but that, when planned to follow the guidelines that characterize this methodology, turns them into attractive and motivating proposals for students. Games are a support tool, whose conception and design must support the established learning objectives and the acquisition of transversal skills [18]. To achieve so, it is necessary for the game-based activity to include not only extrinsic motivational elements (such as incentives or prizes) but also intrinsic motivational elements (such as progress in learning and personal satisfaction).

Csikszentmihalyi (1990) [19]identifies the main factors that must be included in a learning game activity to be playful and useful at the same time: i) it must challenge the students' personal skills and knowledge; ii) the objectives must be clear and concise and must provide feedback (for both students and teachers); and iii) it must be adaptable / flexible over time.

Thus, gamification is not only a useful methodology to achieve learning objectives for the student, but also from the teachers' perspective. Among the advantages of its implementation, gamification can: help manage the class, improve the classroom environment and reduce learning times. That is one of the main reasons behind its wider spread in non-STEM programs (science, technology, engineering, and mathematics) for teaching STEM subjects since these subjects are usually the ones considered more complex [20].

Studies in higher education corroborate the role of gamification in favoring a more active attitude in class, stimulating a more relaxed environment and peer support [21]. Others, such as [22] state that gamification is an obvious and essential direction to follow in university education, since it allows students to become the center of their learning process, while at the same time, it increases motivation and active participation.

2.4 Project-Based Learning (PBL)

It is a student-centred learning methodology in which students acquire an active role and academic motivation is favored. In this method, students are asked to develop a project to solve, usually in teams, a real problem through collaboration, culminating in a final product that addresses and solves the problem under study. This project has been previously analyzed by the teacher to ensure that the student has everything necessary to solve it, and that in its resolution the student will develop all the desired skills. According to Kokotsaki et al. [23], this methodology is based on three constructivist principles: learning is context specific, students are actively engaged in the learning process, and they reach their objectives through social interactions and knowledge sharing.

The key features of PBL are that it begins with a driving question that students must solve using a problem-solving process similar to that which would be developed by a team of experts in the discipline and supported by learning technologies that enable them to see beyond their capabilities [24]. Students also engage in collaborative activities with others involved in the problem to find solutions to the key question, reflecting the complexity of the real problem-solving processes. To complete the PBL, students create a set of tangible products that address the driving question.

The main benefits of PBL are that students develop skills and competencies such as collaboration, project planning, communication, problem solving, decision making and time management as well as individual learning strengths and the practical learning to use technology, it increases students' motivation and self-esteem, it integrates university learning and reality, it develops collaborative skills to build knowledge, it establishes integrative relations between different disciplines [25].

According to Guo et al. [26], the use of PBL in higher education supports the development of four categories of learning outcomes: cognitive outcomes, affective outcomes, behavioural outcomes and artifact performance. Cognitive outcomes are related to knowledge and the cognitive learning strategies that students adopted in PBL. The affective outcomes are associated to students' perceptions of the benefits of using PBL and their learning experience with the use of this methodology. The behavioural outcomes are linked to students' skills and engagement. Finally, artifact performance is related to the documents, objects and multimedia developed by students that are assessed.

2.5 Role-playing games (RP, Role-Playing)

A role-playing game is a game in which players take on a specific business "role" and interpret their dialogues and describe their actions into a predefined story. Cheville (2016) [27] states that a role-playing game is "a textual system consisting of rules for game mechanics, stories (modules) that give meaning and context to the actions of characters and means of social interaction through which a story is co-created" (p. 810). The game mechanics refer to the rules that govern and guide the player's actions, as well as the game's response to them. A game's mechanics thus effectively specifies how the game will work for the people who play it. The players, each one in each role, develop their skills and knowledge through story. The story contains a series of scenarios of increasing difficulty [28]. These challenges can be tactical, social, moral, or strategic and often have multiple solutions, and target higher-level skills in contrast to the drill-and-practice games used to develop memorization [29] [30]. As Prager (2019) [28] states, the main difference between games and role-playing games raises on how

the role-playing emphasizes on the player development within the story. Thus the way the player decides, according to its knowledge, is crucial for the story development and the story can go in one way or another. The player capabilities and knowledge increase along the game, while the story advances. In this regard, the player has a lot of influence on the game development.

There exist different types of role-playing games, including (i) tabletop role-playing game, in which participants determine the actions of their characters based on their characterization, and the actions succeed or fail according to a set formal system of rules and guidelines. Within the rules, players have the freedom to improvise; their choices shape the direction and outcome of the gam (ii) live-action role-playing game, in which the participants in physically portray characters in a fictional setting; and (iii) role-playing video game, in which tabletop role-playing games are translated into a variety of electronic formats. Some authors divide digital role-playing games into two intertwined groups: single-player games using RPG-style mechanics, and multiplayer games incorporating social interaction.

In the context of business role-playing games, the main advantage is that students can practice in physical view the scenes, stories, problems, etc. that occur in a real-world enterprise. Nevertheless, the scenario, the tabletop game or the video game, has to be very well prepared and defined, so that there is no matter of confusion on what the teachers want what the students have learn or experiment.

Many applications are seen in the literature, to mention few ones, the readers can read the works of [28], [31], [32], [33] or [34], amongst others.

2.6 Simulation-Based Learning

Simulation-Based Learning (SBL) is used in the university context for the training of future modelers, especially in technical careers such as: Industrial Engineering, Operations Research, Management Science, or Business Analytics, among others [35]. Simulation techniques are used to analyze current processes (improvement and optimization) and future processes (anticipation of solutions) to obtain the most efficient design with different objectives [36].

SBL represents a teaching methodology that breaks with the traditional system of master classes, since it allows students to receive immediate feedback on the subject being treated, i.e. reception of raw materials, configuration of a server, or the design of the supply chain structure. This freedom of experimentation and speed of response allows students to explore different designs (based on theoretical concepts), which they could hardly experience in real life (it could be dangerous, expensive or unethical in some cases). Thus, this methodology allows them to learn from their mistakes without having to face the real consequences.

From educators' point of view, SBL provides a tool for unlimited experimentation, which complements and extends the classroom experience. In addition, it provides an immediate electronic record of data, which can be used to improve the training process or to design new learning experiences personalized to student profiles (i.e. according to their training interests, skills and abilities). The reproducibility of the results obtained in these experiments also allows comparing different configurations of SBL, making the experience more real and accurate.

In de la Torre et al. (2021) [37], the main contributions of SBL related to circular economy and sustainability processes in different areas are collected: Business and Management (i.e. for analyzing customers' acceptance, managers' selection, or illustrating the potential benefits of new policies); Chemical Engineering (i.e. for process identification); and Architecture and Construction Engineering (i.e. for estimating the energy consumption of materials, or evaluating the efficiency in new designs).

3 RESULTS

The following Table 1 show the main results derived from the review of the different active methodologies analysed

Table 1. Active learning methodologies: review

	Main characteristic	Student work		Advantages	Challenges
		Individual	Collaborative		
Reverse Teaching	Students work autonomously on concrete learning results at home, and more complex learning results are worked in class	At home work less complex learning results	Added value activities in class	• Learning performance; • Student-teacher interaction • Time efficiency • Student autonomy • Individualized and flexible learning	• Students` opposition to new learning methodology in which part of the work is done in home
Game-Based Learning	Games and/or video games in the classroom to learn content and skills		Competitive and entertainment-related elements	• Develops creative and non-standard problem-solving strategies • Deal with learning of transversal skills related to collaborative work or creativity, complex thinking, information and technology	• Motivate and involve the students in the game • Regulate the game according to students' needs
Gamification	Learning activities based on using game elements. Games are a support tool, whose conception and design must support the established learning objectives	Motivational element with progress in learning and personal satisfaction	Competitive and entertainment-related elements	• Manage the class, improve the classroom environment and reduce learning times • Favoring a more active attitude in class, stimulating a more relaxed environment and peer support	• It must be adaptable / flexible over time
Project-Based learning	Students develop a project to solve a real problem through collaboration, culminating in a final product that addresses and solves the problem under study	Individual learning strengths and the practical learning to use technology. Increase self-esteem	Solve, usually in teams a specific problem. Social interactions and knowledge sharing. Learning technologies that enable students to see beyond their individual capabilities	• Collaboration, project planning, communication, problem solving, decision making	• The teacher previously analyzes the project to ensure that the student has everything necessary to solve it, and that in its resolution the student will develop all the desired skills • Integrative relations between different disciplines
Role-playing games	A textual system consisting of rules for game mechanics, stories (modules) that give meaning and context to the actions of characters and means of social interaction through which a story is co-created. The main difference between games and role-playing games raises on how the role-playing emphasizes on the player development within the story	• Player's actions • Students' roles • Game's mechanics thus effectively specifies how the game will work for the people who play it • The players, each one in each role, develop their skills and knowledge through story • Single-player games using	Multiplayer games incorporating social interaction	• The player capabilities and knowledge increase along the game, while the story advances. In this regard, the player has a lot of influence on the game development • Students can practice in physical view the scenes, stories, problems, etc. that occur in a real-world	• The player capabilities and knowledge increase along the game, while the story advances. In this regard, the player has a lot of influence on the game development • The game Has to be very well prepared and defined, so that there is no matter of confusion on what the teachers want what the students have learn or experiment

Simulation	Simulation techniques are used to analyze current processes (improvement and optimization) and future processes (anticipation of solutions) to obtain the most efficient design with different objectives	An student receive immediate feedback on the subject being treated	Students receive immediate feedback on the subject being treated	• Students have freedom for experimentation • There is a speed of response, allowing students to explore different designs (based on theoretical concepts), which they could hardly experience in real life • Allows students to learn from their mistakes without having to face the real consequences • Provides an immediate electronic record of data, which can be used to improve the training process or to design new learning experiences personalized to student profiles	• The simulation has to be very well prepared and defined,

4 CONCLUSIONS

A new way of teaching must be incorporated in the universities, especially because they are the institutions in which the students learn the concepts to be applied in the new jobs that are appearing due to the Industry 5.0. Active learning methodologies are centered on the student, are to be applied in order to achieve the characteristics of the new Industry 5.0 jobs. Within active learning methodologies students are the active learners with self-learning and assessment as a key factor. active learning methods are introduced in classrooms to increase students' problem-solving and critical-thinking capabilities.

Different teaching methodologies are analysed, concluding that they complement each other, leading to reinforce and consolidate learning. The main aim of this work is to review the different active learning methodologies that can be applied at the university classroom, including: (i) flipped teaching; (ii) game-based learning; (iii) gamification; (iv) project-based learning; (v) role-playing games; and (vi) process simulation.

Although active learning methodologies enable students to increase motivation through self-learning activities and collaborative work, there are many challenges to cover in the teaching scope, including: (i) the reduction of students per class, in order to increase students' personalization to meet their needs; (ii) appropriate environments for promoting active learning activities; (iii) materials and resources for this specific way of teaching have to be done; (iv) technologies to deal with learning practices; (v) appropriate planification and evaluation methods, because exams that require memorization are old approaches to evaluate; (vi) institutional support; and (vii) training teachers to apply active methodologies of teaching in their subjects

In future research actions, the state of the art related with the active learning methodologies will include the sustainability research area and how this hot topic area can be adapted to the active learning methodologies. Moreover, we will include novel ways on how to teach sustainability principles by using active learning methodologies.

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