# Emerging technology and teaching methodologies in virtual learning environments

## Tecnologia emergente y metodologias utilizadas por los profesores en la virtualidad

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**ABSTRACT**

As the first part of this research, the theories of constructivism and connectivism were explored, focusing on the most prominent authors in the field. The study highlights key concepts and the emergence of emerging technologies (ICTs). The objective of the research is to analyze emerging technologies and the teaching methodologies used by instructors in the Bachelor's Degree in Information Systems Engineering, which is delivered virtually to first-, second-, third-, and fourth-year students at the Faculty of Informatics Mazatlán. A sample of 30 faculty members from the institution was selected for the initial phase. A hybrid methodology was employed, incorporating a questionnaire consisting of 10 Likert-scale items (ranging from Strongly Disagree to Strongly Agree) and four open-ended questions to collect qualitative data. The results indicate that the most commonly used emerging technologies are the Internet of Things (96,7 %) and collaborative platforms (93,3 %). This suggests that instructors primarily use these technologies for assignments and extracurricular activities, often without providing feedback. Regarding preferred teaching methodologies, the findings reveal that 25 % of faculty members favor expository methods, teamwork, and summative assessment. It is recommended to conduct further research on faculty training for the effective implementation of teaching methodologies tailored to each type of emerging technology.

**Keywords:** Emerging Technologies; Teaching Methodologies; Information Systems Engineering; Virtual Education; Faculty Training.

**RESUMEN**

Como primera parte de la investigación se abordó la teoría del constructivismo y conectivismo sobre los autores más sobresalientes, se ponen en manifiesto los conceptos y surgimiento de las tecnologías emergentes (TICs). El objetivo de la investigación es conocer y analizar las tecnologías emergentes así, como las metodologías utilizadas por los docentes, en la carrera de la Licenciatura en Ingeniería en Sistemas de Información, que se imparte de manera virtual en los grupos de primer, segundo, tercero y cuarto años en la facultad de Informática Mazatlán. Como primera parte se tomó una muestra de 30, docentes que laboran en la facultad. Manejando una metodología hibrida, aplicando un cuestionario de 10 ítems con cinco opciones de respuesta tipo Likert (de Muy en Desacuerdo a Muy de Acuerdo) y cuatro preguntas abiertas para recoger la información cualitativa. Los resultados obtenidos indican que las tecnologías emergentes más utilizadas son el internet de las cosas con un 96,7 % y las plataformas de colaboración 93,3 %, lo cual quiere decir que el docente las utiliza solo para trabajos y actividades extraclases y sin realizar retroalimentación en algunas ocasiones.

En cuanto a la metodología didáctica preferida por los profesores se obtuvo el manejo de los métodos expositivos, trabajo en equipo y la evaluación sumativa con un 25 %. Se recomienda realizar una investigación sobre la capacitación para el manejo de las metodologías más adecuada para cada tipo de tecnologías emergentes.

**Palabras clave:** Tecnologías Emergentes; Metodologías de Enseñanza; Ingeniería en Sistemas de Información; Educación Virtual; Capacitación Docente.

## INTRODUCTION

When discussing emerging technologies in education, new improvements are investigated by implementing digital tools in online teaching to analyze their potential inside and outside the classroom.[1,2] When discussing teaching methodologies, great care must be taken when choosing which ones to use in these environments, as they form the basis for these new ways of learning. This has already been seen during the SARS-CoV-2 pandemic, compounded by new emerging pedagogies that seek to decipher what ICTs can achieve in educational environments. In a sense, new emerging technologies are related to different ways of learning: active, reflective, practical, and theoretical.[3]

ICTs have demonstrated widespread participation and dependence in teaching and learning. Under this premise, new and rich alternatives are presented for educational models to be much more dynamic, effective, flexible, and participatory, where technology and emerging pedagogy are present, according to the author,[4] contributed in many cases; for example, mobile learning, hybrid learning, and flipped classrooms.

Today, all public universities in the country face a technological lag, as they do not have the support of the federal government to address this technological gap. The Autonomous University of Sinaloa is no exception to this situation, specifically the Faculty of Computer Science in Mazatlán, where the idea of conducting this study on new emerging and converging technologies applied to education was born. It is essential to mention that this faculty is responsible for preparing future professionals in Computer Science and Information Systems Engineering. The main objective of this study is to determine the use of emerging technologies and teaching methodologies in the training of FIMAZ students and how they converge in the teaching-learning process.

## THEORETICAL FRAMEWORK

Firstly, we can conceptualize emerging pedagogies as a repertoire of perspectives that are developed through the use of information and communication technologies (ICT) applied to education to be fully utilized in functions such as communicating, informing, collaborating, interacting, enhancing, and innovating the culture of learning.[5] Although many emerging technologies are said to be new, their novelty does not make them relevant; for example, emerging technologies in education may be just new iterations of existing technologies or technological adaptations that have been successfully used in other areas of human activity for schooling. The following section describes the theories that support the use of emerging technologies with emerging pedagogy, focusing on constructivism, connectivism, and experiential learning.

### Constructivism and connectivism theory

The theories of constructivism and connectivism are educational positions that present a variety of perspectives on how human beings achieve and organize what they learn. These theories substantially support the design of pedagogical strategies in this new digital era. Describing each of them specifically, we can identify that constructivism's basic idea is that learning is an active and not a passive process by which students manufacture or construct their own knowledge through interaction with the world. The main authors of this theory are Jean Piaget and Lev Vygotsky.

With his studies and contributions (1986-1980) on the theory of cognitive development research, Jean Piaget affirms that there are stages of mental development, which consist of how infants' thoughts evolve as they develop. This study is divided into four stages: a) Sensory-motor stage in ages 0 to 2 years: This first stage postulates that babies acquire knowledge through their senses and motor actions; b) Pre-operational stage in ages 2 to 7 years: For the second stage, children begin to use language and symbolic thinking; c) Concrete operations stage from 7 to 11 years: Children develop the ability to think logically about concrete objects and understand concepts such as conversation; and d) Formal operations stage from 11 years onwards, here it is postulated that individuals can think abstractly and perform hypothetical and deductive reasoning.

### Assimilation and Accommodation Processes

Jean Piaget's study proposes two cognitive keys to explain how children acquire knowledge: assimilation and accommodation.

Assimilation talks about incorporating new knowledge or experiences into our existing information. Assimilation plays a vital role in how humans learn. Humans constantly learn new information and experiences from a very young age to build new knowledge. It is essential to mention that this development phase does not stop as we grow up. It is constantly adjusting our ideas and experiences and learning about the world.

Regarding accommodation, Jean Piaget affirms that it is a process that can be learned in knowledge since it allows us to modify our ideas to have new information. The accommodation method involves modifying schemas or the same existing ideas so that new schemas can be created during the learning process. For example, when children use a tablet, they believe it is a computer because it shows and solves some situations. Still, when they grow up and realize that tablets are not computers, they will undergo a process of accommodation in which their existing schemas for tablets are modified. They will also develop new schemas for personal computers.

Piaget states that schemas become increasingly refined and detailed as new ideas and beliefs are incorporated, which is also true for adults.

When a child who all his childhood was educated about the behavior that could be inappropriate of the opposite sex when he, grows up and leaves home to study at a university, he may find himself surrounded by people of the female sex. Through authentic experiences and interactions with this group, he realizes that his previous knowledge about this group is incorrect, leading to a drastic change, accommodating his schemas about the people in this group and modifying the existing schemas to adapt to the new information or knowledge.[6]

Lev Vygotsky places great importance on social interactions and culture for cognitive development. He proposed that learning and human development are essentially sociocultural processes. Therefore, cognitive development occurs through interaction with other individuals at school or in everyday situations. He mentions that knowledge is transmitted from one generation to another through teaching and social collaboration.

His fundamental concept in this theory was the so-called "zone of proximal development" or ZDP, which is nothing more than the space between what the student or any person knows at this moment and how far they could go with the help of more competent people, receiving guidance and support from a tutor or a more capable peer. This guidance will give the individual new skills and knowledge that they can eventually perform independently.

Another concept within Vygotsky's theory is mediation (with other people) and mediating tools such as language because as learners interact with other more competent speakers, they organize their thoughts, understand more things, and thus solve problems.

For example, when we have students studying the first year of computer science and when establishing this measurement with their peers, future graduates, they understand through explanation (speech) the performance and importance of each of the subjects within their academic training.

Vygotsky's theory currently significantly impacts education and pedagogical approaches: collaborative learning, problem-based learning, and student-centered teaching. The approach promoted by Vygotsky's theory is based on the idea that learning is a social process and that education should encourage active participation between students and educators.[7]

Today, a range of authors share clear ideas about the inclusion of the use of emerging technologies in the teaching-learning process. The following table summarizes the authors and their main contributions that promote more dynamic and meaningful learning:

Seymour Papert: Pioneer in the use of technology in education, known for his work on constructivist learning and his focus on using computers to foster critical thinking. Research by[8] shows that using digital technology with a constructionist approach significantly expands the variety and complexity of projects that children can undertake. This facilitates the implementation of active learning. In this sense, digital technology has the potential to revitalize progressive education, giving it a new opportunity to consolidate itself in educational environments.

In research by [9] founder of Khan Academy, he has promoted online learning through digital resources to improve education and promote accessibility and self-directed learning. In his book, he makes several outstanding contributions, including a reflection on different approaches to learning. He raises questions such as whether it is better to focus on the theoretical, the practical, the visual, or the verbal or whether to use traditional projects or problems. In the face of these questions, he suggests that it is unnecessary to opt for only one alternative since technology makes it possible to integrate both options in a complementary manner. Khan does not propose a single theory but a series of concrete practices that have proven effective and can be further refined. During the development of Khan Academy, he sought to solve key learning problems, such as identifying and overcoming gaps in students' prior knowledge.

In contrast, the author [10] promotes the creation of learning environments where students actively participate in their construction, integrating emerging technologies that stimulate problem-solving and critical thinking. In this approach, computers are conceived to enhance meaningful learning and knowledge construction in higher education. Rather than being limited to the transmission of information, their use should be oriented to facilitate reflection and critical analysis of the ideas that students are studying. In addition, using computers as

"Tools of the Mind" allows, through software applications that act as representations of knowledge, to speed up and deepen the understanding of content, going beyond the scope of traditional computer-assisted instruction.

On the other hand, [11] promotes project-based learning and content creation through emerging technologies, highlighting the relevance of creativity as an essential element in the learning process. This approach proposes that using technological tools, such as Crickets and Scratch programming languages, favors the development of creative thinking. The methodology is based on the so-called "creative thinking spiral," in which students imagine what they want to do, develop a project from their ideas, experiment and explore their creations, share their ideas with others, and reflect on their experiences. This process is repeated continuously, allowing students to generate new ideas, test them, challenge limits, experiment with alternatives, receive feedback, and improve their projects based on their previous experiences. This approach encourages autonomy, experimentation, and collaborative learning.
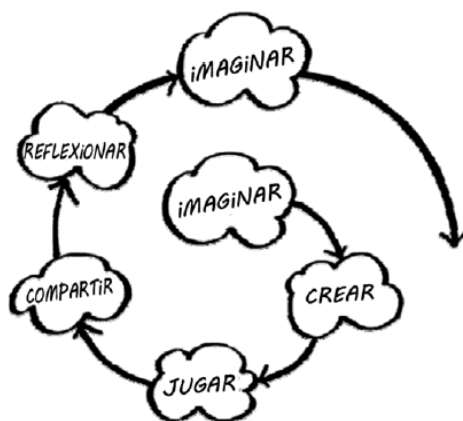


**Source:** Resnick, 2008
**Figure 1.** Spiral of creative thinking designed by Dr. Mitchel Resnick

The story goes that the first computers in the 1940s to 1950s, the electronic computers used to take the first national census in the United States, ENIAC (acronym for Electronic Numerical Integrator and Computer). It occupied a space of 167m2 and had 17 500 vacuum valves, 72 000 crystal diodes, 1 500 relays, 70 000 resistors, 10 000 capacitors, and 5 million soldering irons. For this macrocomputer, several people needed to ensure that no vulva failed because they always melted when the valves were turned on. In this generation, many other companies developed several computer technologies, new, more efficient computer models, operating systems, programming languages, etc. The companies that ventured into this activity were IBM, Apple, Microsoft, Xerox, to mention a few.[12]

By approximately 1960, computer networks emerged, the most popular of which was Arpa (Advanced Research Projects Agency), the precursor of Arpanet and the Internet. This network was founded by the Ministry of Defense of the United States of America, and its main objective was to establish direct communication with other research bases. After Arpa emerged, a more sophisticated network called Arpanet was created, which initially had 40 points or nodes connected in different locations. This marked the beginning of the appearance of other networks, such as Telenet in 1974, Usenet in 1979, Bitnet in 1981, and Eunet in 1982.

According to [13] by the end of 1982, ARPANET had adopted the TCP/IP protocol, and at that time, the Internet (International Net) was created.

With the advances in computing over the years, new and better tools have emerged to support education and industrial companies, such as artificial intelligence and augmented reality, which began to develop in 2020. As has been explained in many scientific articles, artificial intelligence is defined as: "

It allows computer applications to mimic human intelligence, solve problems, make predictions, and provide solutions".[14]

According to UNESCO, since AI's inception, there has been a search for new tools to be included in education around the world. It determines that students and teachers use AI for different purposes: to create, write, program, etc. In addition, various valuable applications applicable to the teaching-learning process have been identified, such as the design of advanced study programs, personalized tutoring, personalized learning content, and prediction of school dropout rates.[15]

Another significant advance in emerging technologies is augmented and virtual reality, which we can define as "a technology that superimposes digital information, such as images, text, or sound, onto our perception of the real world".[16] When talking about augmented reality, it is essential to make a significant distinction between it and virtual reality. AR enriches our current experiences by integrating digital elements, combining

the real world with the virtual world, offering real-time interaction, and interacting with the physical spaces of the environment. These characteristics are not provided by virtual reality.

We can apply augmented reality tools to reduce the use of interactive books, known as "magic books." The Chromville app allows you to discover animal and cultural life; BodyPlant will enable you to learn about the human body; Arloon is a set of programs useful for subjects such as mathematics and physics aimed at different levels of learning. There are numerous applications for creating augmented virtual reality, to name a few: Layar is free for smartphones, Metaverse web application is for use on computers or smartphones, and Merge app is for creating three-dimensional objects in digital form.

Emerging technologies? The resources and tools offered by ICTs give us a wide range of options that we can apply to educational processes when training our students. Transmission, storage, collaboration, communication, digital skills development, and information processing make accessibility and interactivity possible in student learning, which are goals we strive to achieve every day.

The term "emerging technology" is often heard in educational settings at our university. George Veletsianos (2010) defines it as follows: "Emerging technologies are tools, concepts, innovations, and advances used in various educational contexts to serve various purposes related to education. Furthermore, I propose that emerging technologies ("new" and "old") are evolving organisms that experience cycles of hype and, while potentially disruptive, have not yet been fully understood or sufficiently researched."[17]

Based on this definition, it is still unclear how to get the most out of this emerging technology. It is clearly underutilized in all educational settings, as it has not entirely eliminated school failure and dropout rates.

Despite their challenges, emerging technologies play a fundamental role in education. Their application in teaching processes has allowed for continuous adaptation and shaping of learning, simplifying, in a way, the traditional teaching-learning process. These technologies include approaches such as e-learning, blended learning, mobile learning, C-learning, P-learning, T-learning, learning analytics, and S-learning, as well as tools such as augmented reality, virtual worlds, gamification, and MOOCs (Massive Open Online Courses), among other resources. In the research carried out, the main emerging technologies most used in the academic field, both by students and teachers, were selected based on the proposals of various authors. Among them, the following stand out: Artificial Intelligence, according to studies by Geoffrey Hinton, Yann LeCun, and Yoshua Bengio; the Internet of Things (IoT), propuesto por Hakima Chaouchi; y la Realidad Aumentada y Realidad Virtual. (See figure 2)



**Figure 2.** Gear: Methodology, emerging technology, and learning

## METHOD
### Approach and design

This study adopted a mixed approach (quantitative and qualitative) to address the research objective. The quantitative approach seeks to discover the causes of events through the observation of evidence, data collection, and subsequent analysis. In contrast, the qualitative approach aims to understand social reality by categorizing information and establishing relationships between the data obtained. To ascertain the participants' level of perception, a mixed approach was chosen as an exploratory strategy to gain a broader view of the phenomenon under study. A non-experimental descriptive design based on surveys was used for the quantitative approach. In contrast, the qualitative approach involved a process of data reduction, categorization, and

coding based on the responses to open-ended questions included in the questionnaire.

## Participants

The sample consisted of 30 participants in the Bachelor's Degree in Information Systems Engineering (LISI) educational program at the Autonomous University of Sinaloa, corresponding to students in their first four years who are studying online. The sample was selected based on inclusion criteria, being enrolled students. The distribution by year was as follows: seven first-year students, eight second-year students, seven third-year students, and eight fourth-year students aged 18 to 24. The research was conducted during the first semester of 2024.

The authors of this study administered a questionnaire designed and validated by them. It consisted of 10 items with five Likert-type response options (from "Strongly Disagree" to "Strongly Agree") and four open-ended questions to collect qualitative information. The questionnaire was administered online through the Google Forms platform, and it was estimated that participants took approximately 15 minutes to complete it. All participants were informed about the study's objectives and gave their informed consent to participate, guaranteeing the confidentiality of their responses.

## RESULTS AND DISCUSSIONS

Figure 3 shows the data in percentages of participants' responses regarding the emerging technologies most frequently used by teachers in virtual mode.

| Herramientas Emergentes aplicada por los docentes | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Inteligencia Artificial | 6.7 | 10.0 | 40.0 | 23.3 | 20.0 |
| Realidad virtual/Aumentada | 56.7 | 16.7 | 13.3 | 6.7 | 6.7 |
| Big Data y análisis de aprendizaje | 36.7 | 30.0 | 26.7 | 6.7 | 0.0 |
| Plaforma de colaboración: Google Works pace, Microsoft Temas y Zoom, sigal. | 0.0 | 6.7 | 0.0 | 26.7 | 66.7 |
| Gamificción | 3.3 | 6.7 | 20.0 | 20.0 | 50.0 |
| Robótica | 10.0 | 6.7 | 70.0 | 6.7 | 6.7 |
| Internet de las cosas | 0.0 | 3.3 | 0.0 | 6.7 | 90.0 |

**Figure 3.** Use of emerging tools
(0 = None; 1 = Low; 2 = Medium; 3 = High; 4 = Very high. Data expressed as a percentage.).

After analyzing data related to teachers' use of emerging tools in the virtual teaching-learning process, the following conclusions were reached:

Artificial Intelligence: The highest level recorded was medium (value 2), with 40 % of teachers indicating moderate use of this tool. This suggests that teachers have used it occasionally, although they may not have the appropriate infrastructure, or the content may not encourage regular use.

Virtual Reality: 56,7 % of teachers reported zero use (value 0), indicating that they have never used this tool in their teaching.

Big Data and Learning Analytics: The predominant level for these tools was zero (value 0), with 36,7 % of teachers indicating that they have not used them.

Collaboration Platforms: Collaboration platforms showed a high use percentage, with 66,7 % of teachers reaching level 4 (very high use), suggesting that these tools are widely used in the virtual modality.

Gamification (computer games): Gamification reached a high level (value 4) with 50 % of teachers, indicating significant adoption of this tool.

Robotics: The use of robotics tools is at a medium level (value 2), with 70 % of teachers reporting moderate use of this technology.

Internet of Things (IoT): IoT use is high (value 4), with 90 % of teachers indicating it as a tool frequently used in virtual teaching.

It is important to remember that the levels of use of emerging tools or new technologies were classified as follows: Level 0: Not used; Level 1: Very low use; Level 2: Moderate use; Level 3: High use; and Level 4: Very high use. (See figure 3)
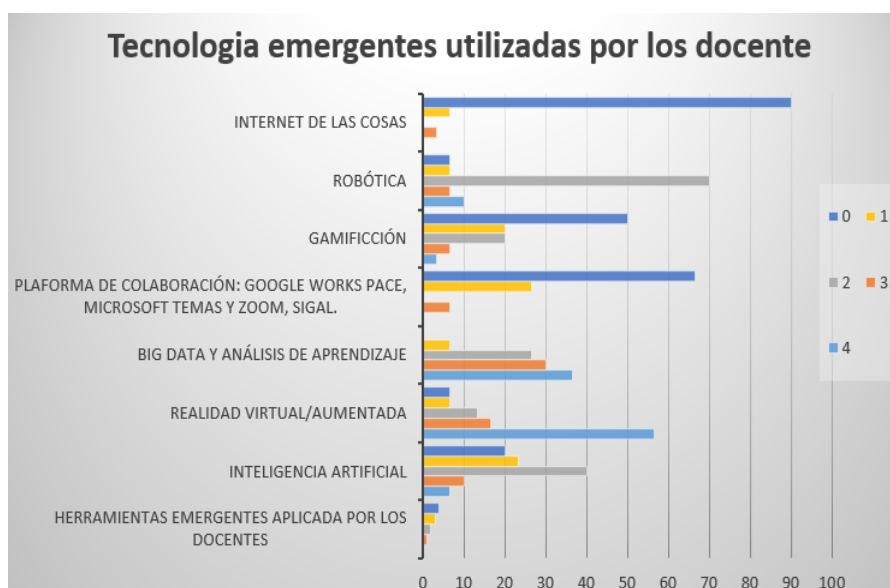
**Figure 4.** Use of emerging technologies by teachers

According to the data obtained, of the total number of teachers who teach virtual classes at the university, only 43,3 % use artificial intelligence as a learning support tool, while 56,7 % do not. As for virtual reality, only 13,3 % of teachers use it, while 86,7 % do not incorporate it into their teaching. Regarding Big Data and learning analytics, only 6,7 % of teachers use them, while 93,3 % do not.

93,3 % of teachers use collaboration platforms (such as Google, Microsoft Teams, and Zoom, among others), while 6,7 % do not. In the case of gamification, 70 % of teachers use it, while the remaining 30 % do not. As for robotics, only 13,3 % of teachers integrate it into their classes, while 86,7 % do not.

Finally, regarding the Internet of Things (IoT), 96,7 % of teachers use this technology in their teaching, while 3,3 % do not.

These results were obtained from a questionnaire administered to teachers at the Faculty of Computer Science in Mazatlán, UAS (see figure 5).
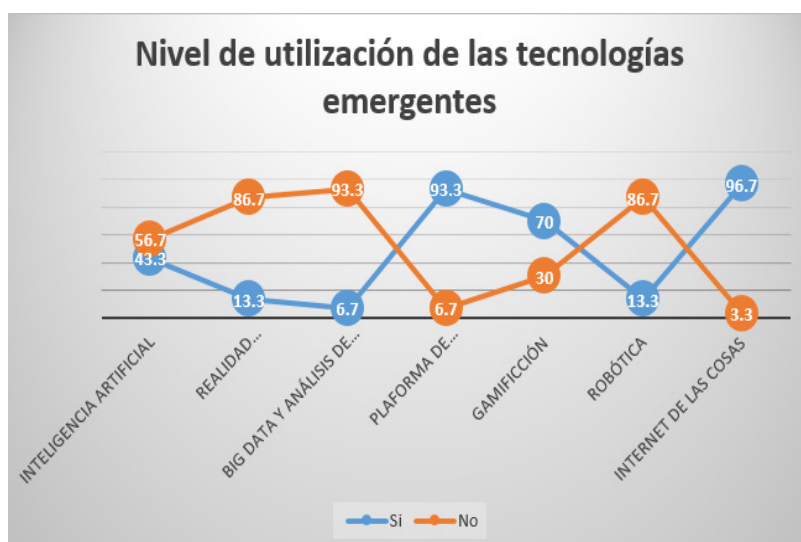


**Figure 5**. Use of emerging tools by teachers

Figure 6 analyzes the different methodologies used by teachers who teach virtual classes in the Bachelor's Degree in Information Systems Engineering program in the first, second, third, and fourth years.

It can be seen that the use of the lecture method ranges from 60 % to 80 %; the expository method varies between 40 % and 65 %; problem solving and exercises range from 30 % to 50 %; Summative assessment ranges from 70 % to 95 %; teamwork and collaborative learning is between 30 % and 55 %; and finally, the flipped classroom methodology is used between 20 % and 25 %.

| Metodología utilizadas por profesores | Porcentaje |
|---|---|
| Clase magistral | 60% - 80% |
| Método expositivo | 40% - 65% |
| Resolución de problemas y ejercicios | 30% - 50% |
| Evaluación Sumativa | 70% - 95% |
| Trabajo en equipo y Aprendizaje colab | 30% - 55% |
| Aula Invertida | 20% - 25% |

**Figure 6.** Types of methodologies used online

## CONCLUSIONS

The technologies with the highest incidence among teachers who teach online in the ISI program in the first, second, third, and fourth years are the Internet of Things (43,3 %) and collaboration platforms (93,3 %).

The measurement parameters strongly disagree, disagree, and indifferent (0,1 and 2), corresponding to 35 % of teachers are indifferent to using emerging technologies, perhaps due to a lack of knowledge or a desire not to use them. This could be a proposal for a future study. However, at least 65 % of teachers have used emerging technology to teach at some point, with the most commonly used being the Internet of Things at 96,7 % and collaboration platforms at 93,3 % (Team, Google, etc.).

Teachers who teach virtual subjects must be prepared and willing to use the latest emerging technologies in the teaching-learning process, as this is required by the new times. When we talk about methodologies, we see a wide range of them. The research carried out determined that the teachers analyzed in this research mainly use lecture methodologies and summative assessments. It is recommended that an existing methodological combination be used according to the needs and requirements of the subjects and the emerging technology taught.

Teachers should be trained in the practical use of emerging tools and in the design of pedagogical strategies that integrate them. Participation in educational communities and knowledge networks where teachers can exchange good practices and resources should be encouraged.

It should not be forgotten that emerging technologies simplify the implementation of innovative methodologies, such as project-based learning, gamification, distance education, etc., adapting to different learning styles. Digital technologies, such as emerging tools, are recommended as they stimulate creativity and critical thinking, allowing teachers and students to create and explore content effectively for their daily work.

It is recommended that teachers design extracurricular activities such as workshops or sessions to train students in the use of emerging tools and foster pleasant environments where students can learn and apply the tools without pressure.

Encourage the use of emerging technologies throughout the semester, citing some activities to be carried out, for example:

• In the use of Artificial Intelligence: Implement intelligent tutoring systems, such as Socrative or Knewton, that provide immediate feedback to students and adapt content to their needs, or use data analysis platforms such as Google Analytics or Tableau to report on student progress and make decisions to adjust teaching.

• Augmented reality (AR) and virtual reality (VR): Implement VR simulators, such as those available on Oculus, or platforms such as Labster, to create virtual laboratories where students can conduct experiments in a safe and fun way.

• The field of robotics is not limited to teaching programs and technologies. It can be integrated into many other academic areas, such as mathematics, to teach concepts such as geometry when navigating geometric shapes. In algebra, a robot can perform tasks based on variables. In language and science, art, and design, among other areas.

• Gamification has the advantage of offering rewards for student success and participation by integrating a system of points or trophies for students to complete activities or participate in classes, thereby achieving the learning objective. Teaching strategies can be established in this area, such as gamifying assessment processes, giving students the opportunity to choose their own learning pace, and providing immediate feedback, among other activities.

Further research is needed on emerging technologies and the methodologies teachers use in virtual environments. It is also essential to investigate the advantages and disadvantages teachers and students report when using these tools. In addition, it is necessary to learn about the different methodologies for virtual classes, which will provide a better understanding of the situation and enable more effective action planning.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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