




Effectiveness of Education 4.0, e-learning and traditional methodology in achieving university research competencies

Efectividad de Educación 4.0, e-learning y metodología tradicional en el logro de competencias de investigación universitaria

Eficácia da Educação 4.0, do e-learning e da metodologia tradicional na obtenção de competências de investigação universitária

José Labori¹

Universidad de Aconcagua, Calama – Antofagasta, Chile

 <https://orcid.org/0000-0002-2161-156X>
joselabori47@gmail.com (correspondence)

DOI: <https://doi.org/10.35622/j.rie.2024.01.007>

Received: 05/12/2023 Accepted: 10/03/2024 Published: 28/03/2024

KEYWORDS

education 4.0, e-learning,
higher education,
research competencies,
statistical competencies.

ABSTRACT. In this study, the effectiveness of three educational methodologies: Education 4.0, traditional education, and e-learning, was sought to be compared in the development of investigative and statistical competencies among university students. A quantitative-qualitative research was conducted with a sample of 96 students from the University of Aconcagua (Chile) during the period between August and December 2023. Data collection was carried out through "ad hoc" surveys designed to meet validity and reliability standards. The results indicate that the use of Education 4.0 showed a significant increase in statistical competencies, particularly in the handling of Power BI software, reaching 73.61%, contrasted with the 5.56% observed in students who only used e-learning ($p < 0.001$). Furthermore, the evaluation of statistical competencies for research, measured on a scale from 1 to 5, where 5 represents the maximum level, obtained an average of 4.355 in the group that applied the methodology with Education 4.0, significantly surpassing the 3.429 obtained with the traditional method ($p < 0.05$). In conclusion, the findings suggest that Education 4.0 proves to be a more effective strategy than e-learning and traditional teaching for the development of statistical and investigative competencies. These results provide solid grounds for promoting an innovative and practical approach in the comprehensive training of future professionals.

PALABRAS CLAVE

competencias
estadísticas,
competencias para

RESUMEN. En este estudio, se buscó comparar la efectividad de tres metodologías educativas: Educación 4.0, educación tradicional y e-learning, en el desarrollo de competencias investigativas y estadísticas entre estudiantes universitarios. Se llevó a cabo una investigación cuantitativa-qualitativa con una muestra de 96 estudiantes de la Universidad de Aconcagua (Chile) durante el período comprendido entre agosto y diciembre de 2023. La recolección de datos se realizó

¹ Master degree in Teaching and Research in Higher Education from the University of Aconcagua, Chile.



investigación, educación 4.0, educación superior, e-learning.

mediante encuestas "ad hoc", diseñadas para cumplir con estándares de validez y confiabilidad. Los resultados indican que el uso de Educación 4.0 demostró un incremento significativo en las competencias estadísticas, particularmente en el manejo del software Power BI, alcanzando un 73.61%, en contraste con el 5.56% observado en estudiantes que solo utilizaron e-learning ($p < 0.001$). Además, la evaluación de competencias estadísticas para la investigación, medida en una escala de 1 a 5, donde 5 representa el nivel máximo, obtuvo una media de 4.355 en el grupo que aplicó la metodología con Educación 4.0, superando significativamente los 3.429 obtenidos con el método tradicional ($p < 0.05$). En conclusión, los hallazgos sugieren que la Educación 4.0 resulta una estrategia más efectiva que el e-learning y la enseñanza tradicional para el desarrollo de competencias estadísticas e investigativas. Estos resultados proporcionan fundamentos sólidos para impulsar un enfoque innovador y práctico en la formación integral de futuros profesionales.

PALAVRAS-CHAVE

competências estatísticas, competências de investigação educação 4.0, e-learning, ensino superior.

RESUMO. Neste estudo, buscou-se comparar a eficácia de três metodologias educacionais: Educação 4.0, educação tradicional e e-learning, no desenvolvimento de competências investigativas e estatísticas entre estudantes universitários. Foi realizada uma pesquisa quantitativa-qualitativa com uma amostra de 96 estudantes da Universidade de Aconcagua (Chile) durante o período entre agosto e dezembro de 2023. A coleta de dados foi feita por meio de pesquisas "ad hoc" projetadas para atender aos padrões de validade e confiabilidade. Os resultados indicam que o uso da Educação 4.0 mostrou um aumento significativo nas competências estatísticas, particularmente no manuseio do software Power BI, alcançando 73,61%, em contraste com os 5,56% observados em estudantes que apenas utilizaram o e-learning ($p < 0,001$). Além disso, a avaliação das competências estatísticas para pesquisa, medida em uma escala de 1 a 5, onde 5 representa o nível máximo, obteve uma média de 4,355 no grupo que aplicou a metodologia com Educação 4.0, superando significativamente os 3,429 obtidos com o método tradicional ($p < 0,05$). Em conclusão, os resultados sugerem que a Educação 4.0 se mostra uma estratégia mais eficaz do que o e-learning e o ensino tradicional para o desenvolvimento de competências estatísticas e investigativas. Esses resultados fornecem bases sólidas para promover uma abordagem inovadora e prática na formação integral de futuros profissionais.

1. INTRODUCTION

Education has gone through constant evolution, having a wide variety of teaching methodologies. For Calle-Suárez & del Rocío Quichimbo-Rosas (2021) there is the traditional school, the new school, the technocratic school and the critical school. In this classification, the traditional school has teacher-centered teaching, which is why its methodology is based on verticalism, authoritarianism, verbalism, memorization and intellectualism.

As a result of the demands of industry 4.0 in terms of skills and technology, education 4.0 was born as a change in thinking at the following levels: (1) Skills, (2) Teaching and learning strategies, (3) Information technologies and communication (ICTs) and (4) Infrastructure (Akimov et al., 2023). The present research seeks to compare the effectiveness in the application of an approach based on education 4.0 with strategies typical of traditional school and e-learning, this for the development of statistical competencies applicable in university research. To create a context, we proceed to define different variables to be worked on:

E-learning has been defined as a system of digital technologies that provide students with a personalized and interactive learning environment to improve learning processes (Martinez-Garcia et al., 2023). Research competencies can be defined as the mobilization of knowledge to make decisions regarding research in order to solve a problem or scientifically study a topic (Almeyda Vázquez et al., 2019). The other variable to be managed will be the number of specific basic competencies in the management of vital statistical software in industry 4.0, being Power BI (Business Intelligence), which is a tool that provides notable improvements in the quality of business decision-making, with complete information management and processing (Vásquez et al., 2022).

Among the most notable antecedents are similar investigations, such as that of Ciolacu et al. (2023) in which a new paradigm in Education 4.0 is studied, from the delivery of knowledge in traditional methodologies, to its creation, in the preparation of practical business skills (Oliveira & Saraiva, 2023) and a greater human-machine integration in decision making and complete learning (Tvenge & Martinsen, 2018). Other studies have seen the improvement in statistical skills using active methodologies, as opposed to traditional methodologies (Ortiz & Vilchez, 2020), in addition to promoting the creation of more methodological strategies aimed at the formation of research skills (Romaní-Romaní & Gutiérrez, 2022).

Problematizing the topic of study, despite there being various studies that highlight the effectiveness of Education 4.0 applied to a blended environment (Ciolacu et al., 2020; Ciolacu & Svasta, 2021; Muawiyah et al., 2018; Raman & Rathakrishnan, 2019), there is a need for a step-by-step description of a methodology that has been experimentally tested, as well as the comparison of different approaches to achieve industry 4.0 competencies (Stek, 2022).

Likewise, there are conclusions from other studies such as those highlighted by Regmi & Jones (2020) regarding the deficiencies of e-learning in various aspects, such as collaboration between students and their centralization in learning. It has been observed that traditional educational methodologies also lack practicality, student motivation, promotion of full immersion learning, and meaningful learning (Ruano et al., 2021).

As justification for the study, the contribution represented by the promotion of competencies for scientific research in higher education is highlighted, contributing to the development of higher-order cognitive skills with a sustained and innovative training process (Velandia Mesa et al., 2019). In addition, technological innovations such as the use of software for business intelligence have been relevant in industry 4.0 (Özköse & Güney, 2023), however, the learning of such tools has had a difficult reception by educational centers (Hmoud et al., 2023), and therefore, it should be promoted more in this area.

The main objectives of the research are the following: Create the bases of a methodology based on Education 4.0 adapted to blended attendance in a continuity of studies program, apply said methodology in two engineering sections in evening format, determine statistical competencies in applications associated with scientific research and in such practical environments in industry 4.0 as in the use of Power BI software. Likewise, we want to contrast the data obtained previously with those of a control group with students also linked to statistics but using other methodologies, such as that of traditional school or using e-learning. Finally, we want to analyze these results together with the qualitative perception of the students, thus evaluating the effectiveness of the methodological proposal created.

2. METHOD

Type of study

To guide the investigative process, a mixed approach investigation was used, being a strategy that pursues a deeper and more complete understanding of the phenomenon in question with quantitative and qualitative elements (Zúñiga et al., 2023). The scope of the research has been explanatory, since with the control group and the manipulation of the variables experimentally, the aim is to analyze a cause-effect relationship in the research (Arias González & Covinos Gallardo, 2021). Likewise, there is an experimental design with pretest-posttest and control group, since the participants have been randomly assigned to two groups and then the test



has been applied simultaneously; one group receiving the intervention and the other not (the control group) (Hernández-Sampieri & Mendoza, 2020).

Population and sample

The research universe is made up of students from the University of Aconcagua, Chile, specifically at the Calama campus, Antofagasta region. Sampling has been simple random, since a representative sample has been obtained with individuals with equal probability of being chosen (Bastar, 2019). The criteria to delimit the population were being over 18 years old, being a student with less than 50% absences in the electrical engineering, industrial engineering, industrial civil engineering, and psychology careers during the 2nd semester of 2023, having studied subjects associated with probability and statistics, in addition to voluntarily participating in the research, having a total sample of 96 students.

Data collection instruments

As research techniques, two questionnaires created “ad hoc” for the characteristics of the study were used. In the quantitative data collection, a 10-item questionnaire was used to measure the level of statistical competencies for scientific research in Higher Education, this with a Likert scale from 1 to 5, in which 1 indicated that the topic presented was unknown and 5 represented mastery of the topic; In addition, a 10-item questionnaire was used that compared the number of basic statistical competencies of the Power BI software, answering Yes/No to the specific objective that was presented.

The instruments were satisfactorily validated with the expert judgment method; A pilot test was also carried out with 30 students, resulting in a Cronbach's alpha coefficient greater than 0.80 in both cases, thus meeting the validity and reliability criteria to carry out the research (Oviedo & Campo-Arias, 2005). To complement the research with qualitative data, a self-administered survey was used for students using open questions to be completed in writing.

Data collection procedure and analysis

To collect data, a self-administered questionnaire was applied; this was provided to the students for the first time during the second week of the 2nd semester of 2023, in both the control and research groups. The intervention was then applied and a second data collection was applied at the end of said semester, also taking into account the control group and with the consideration of applying open questions only in this final data collection, to gather a more complete perception of part of the students. Data collection was carried out digitally, using the free programs “Google Forms” and “Microsoft Excel”, allowing the order of the data in tables with filters and the subsequent generation of statistical parameters.

Various statistical parameters were used to analyze the data, such as the chi-square test, since it statistically compares an experimental frequency with a theoretical frequency (Tallarida et al., 1987). This test was chosen due to the nature of the instrument used, since when specific Yes or No results were obtained, discrete counts were compared. This result is considered statistically significant as it is less than a reference alpha value of 0.05 (Pandis, 2016).



3. RESULTS

In this part, the findings obtained will be divided into three parts: The description of the blended methodology based on Education 4.0, the quantitative results with their statistical indicators and finally the qualitative results, with the general opinions of the students.

Methodology for Blended Education 4.0. In other studies, a methodology based on Education 4.0 focused on technical careers has been proposed, covering the needs of Industry 4.0 by combining theory, active learning and a semester project (Labori, 2023). Each of the 3 previous parts are detailed below:

Part 1: Theoretical-practical foundations

In a degree within a Continuity of Studies Program in blended mode, special emphasis must be placed on the delivery of activities before the face-to-face meeting, so that the student has the opportunity to read the contents before entering class, advance the activities of application of each session and actively take advantage of the non-contact hours allocated to the subject 3 or 4 days in advance.

The face-to-face session begins with a brief master class, exposing the basic theoretical foundations, developing examples in detail, orienting the content towards the application of knowledge, covering between 30 and 40% of the class time and taking advantage of the combination of passive and active (Gagné et al., 2021).

Part 2: Active learning class by class

After the theoretical part, we proceed to propose activities related to the application of the knowledge provided, which may be solving problems and explaining them in front of the class. However, when the number of students exceeds 15, it is recommended to design the activities with fewer one-on-one explanations on the blackboard and more parallel study, in order to take advantage of the limited time of the sessions at the study center and promote greater equality of opportunities among students to participate. This discernment in the type of activities to be developed has been proposed by March (2006), since it promotes the maintenance of teacher-student interaction.

Part 3: Semi-annual group projects

Project-based learning forms an important part in the training of university students, since it encourages teamwork, critical thinking and problem solving (Asunción, 2019). From the beginning of the educational period, groups of 2 to 3 students must be formed to undertake a project related to the application of knowledge of the field to be discussed. This project will receive feedback from the teacher since it will form 40% of the weight in the partial evaluations in the subject.

In summary, the three previous parts were adapted to in-person attendance and summarized in Table 1.



Table 1

Summary of the blended methodological proposal based on Education 4.0, applied in engineering.

University: University of Aconcagua. Chile.				
Class format: Blended learning.				
Participants: 30 students from the Industrial Engineering degree.				
Subject: Probability and statistics (1st year)				
Parts	Basic components of Education 4.0			
	1. Competencies	2. Learning methods	3. ICTs	4. Infrastructure
Part 1: Theoretical-practical foundations. 30-40% of the class presenting key theory and examples	Problem solving with critical reasoning	Fundamentals of problem-based learning	Power Point presentations with links to view and create simulations	Rooms with elementary requirements
Part 2: Active learning class by class. Individual or small group class-to-class activities	Creativity, cooperation and analysis of case studies	Student-centered, mostly active learning	Software such as Power BI, Excel and Geogebra for modeling functions	Rooms for teamwork, Non-face-to-face tutorials for basic software management
Part 3: Semiannual group projects. Application work in groups of 2-3 with monthly feedback for scientific poster at the Semiannual Fair and video summary	Quality and innovation in the project, pluralism in contact with other sections and inclusion in dealing with the public	Autonomy in Learning based on projects	Data management software such as Excel, Google Forms and Power Point, Microsoft Teams for recordings	Large room with logistics organized by students. At least one computer per team for final dissertation.

In order for there to be a better adaptation to blended courses, autonomy must be encouraged in the student, directing the content to the creation of innovative solutions, management and interpretation of business databases and managerial applications in which the student requires the use of skills. transversal or character skills such as leadership, empathy, pluralism, resilience, and responsibility.

Quantitative results. The previous methodology was applied in a section of electrical engineering and in another of industrial engineering, both in the 1st year, in the 2nd semester of 2023 and studying the subject "Probability and statistics". During the semester, the topic of real-time statistical data analysis was discussed with the addition of practical activities that included the use of the Power BI tool, including tutorials and emphasizing the importance of the software.

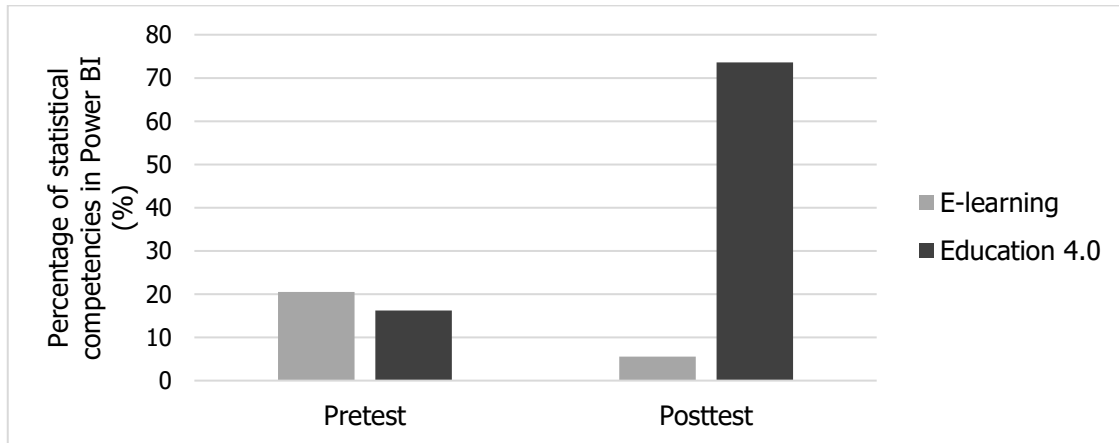
At the same time, there was a control group made up of students with prior knowledge of applied statistics, being 2nd and 3rd year psychology students, who were informed about the importance of using the Power BI software and were provided with tools. e-learning for using the software, such as instructional tutorials and databases to practice. Before and after the previous strategies, they were given the survey in which each student



reported how many specific competencies she considered she managed, having a pre-test and a post-test measurement, summarized in Figure 1.

Figure 1

Bar graph of the percentage of statistical competencies achieved by students



Note. The figure compares the percentage of basic statistical competencies achieved in the use of Power BI in two groups of students: One using a blended methodology based on Education 4.0 and another group using an e-learning methodology.

The research hypothesis in this section of the project is that "If a methodology based on Education 4.0 is applied, then there will be a higher level of statistical skills with Power BI than applying an e-learning methodology", obtaining a notable difference in means in the graph during the post-test and a p value much lower than 0.05, which can even be compared with 0.001 as shown in table 2.

Table 2

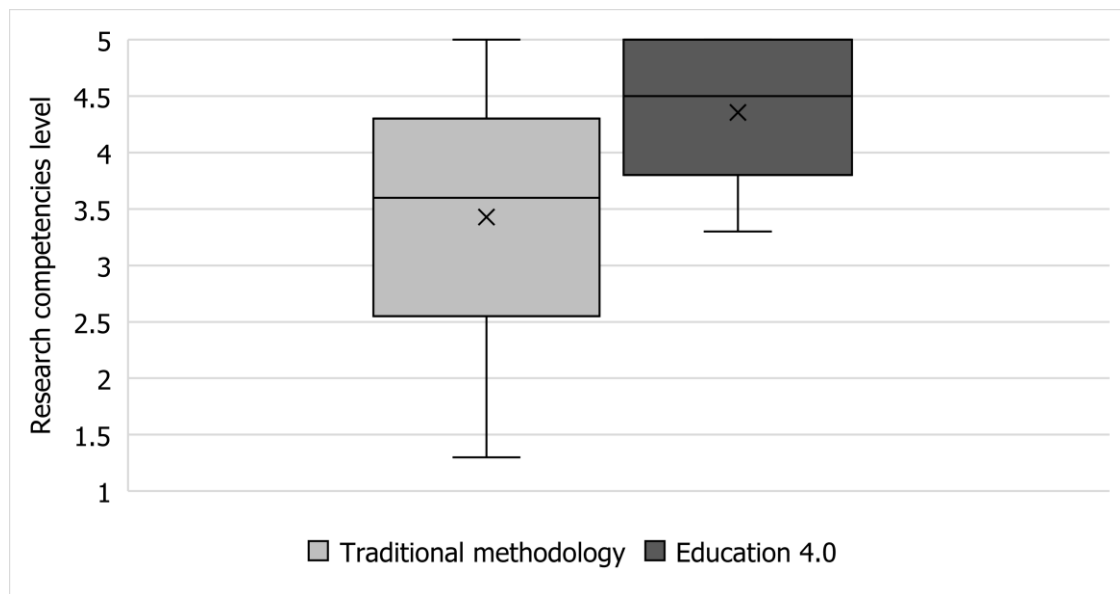
Summary of the level of statistical competencies with Power BI software achieved (The averages of the percentage of specific competencies achieved are shown)

	Pretest	Posttest	p (χ^2 test)
E-learning	20,51%	5,56%	<0.001
Education 4.0	16,20%	73,61%	

At the end of the semester, after implementing the 4.0 methodology in the sections of the subject "Probability and Statistics" of electrical engineering and industrial engineering in the 2nd semester of 2023, the research competencies achieved by said students were quantified, taking into account all strategies included in the methodology. These results were compared with a control group, being students of the industrial civil engineering program who also studied courses based on statistics but with a traditional methodology. This comparison can be seen in Figure 2 below.

Figure 2

Box diagram of the level of research competencies achieved by students



Note. The figure compares the level of statistical skills for research (on a 1-5 Likert scale, with 5 being the maximum level of skills and 1 being the minimum level) in two groups of students: Some using a blended methodology based on Education 4.0 and another group using a traditional methodology.

For the analysis of the previous figure, a Student's t test was considered, being a statistical analysis technique that evaluates the difference between two means (Kim, 2015), obtaining a p value less than 0.05, which can be said that There are statistically significant results.

To quantify and analyze in more detail the difference in means between the two samples, Cohen's d was used as a statistical indicator, which indicates how many standard deviations exist between two sets of data (Rendón-Macías et al., 2021) and was calculated by subtracting the averages of the two samples and dividing the result by the average standard deviation (Cohen, 2013). If the absolute value of said coefficient is close to 0.01, it is considered very small, at 0.20 small (but not trivial), at 0.50 medium or moderate, at 0.80 large, at 1.20 very large and greater than 2.0 it is considered enormous (Sawilowsky, 2009). The values obtained from the d-Cohen coefficient and the p value have been summarized in Table 3.

Table 3

Summary of the level of statistical competencies for research achieved by students using two different methodologies (Likert scale 1-5, with 5 as the maximum level and 1 as the minimum level)

	Mean	Standard deviation	d-Cohen	p (t-test)
Traditional	3,429	1,067		
Education 4.0	4,355	0,612	1,065	0,0374

Qualitative results. At the end of the period in which the research methodology was applied, the students were given the opportunity to write in detail their perceptions about the methodology used in the field associated with statistics. These opinions are intended to complement the numerical results presented previously, thus having a more complete starting point for the analysis of the Blended Education 4.0 methodology and the traditional methodology. The open questions presented were composed of the sections placed in Table 4.

Table 4

Student perceptions of a methodology based on blended Education 4.0 (in fields associated with probability and statistics)

Section	Frequent answers
1. Positive opinions of the methodology used (Education 4.0)	<ul style="list-style-type: none"> — The importance of the semester project is highlighted, since there is practical work close to reality and the challenge of explaining a project to anyone, within the framework of the Technology Fair at the end of the year. — The blended modality allows you to investigate more about the subjects to be covered class by class. — Thanks to data analysis students can carry out improvement projects in their work area. — The use of updated software is valued — The teachings given by the teacher are appreciated in terms of their experiences applying knowledge. — The applicability of the knowledge is highlighted, since it can be used in day-to-day issues and even statistically show solutions in the positions held.
2. Details to improve the methodology used (Education 4.0)	<ul style="list-style-type: none"> — It is thought that there should be more explanatory cases of the exercises treated class by class. — Weekly class hours must be more than 2 for a subject as complete as statistics. — The level of difficulty is sometimes high for those who work, it is difficult to catch up with tasks

Likewise, the students' perceptions of the methodology based on the classical school are presented, with a center on the teacher, a focus on teaching rather than on practical learning and memorization, with the opinions summarized in table 5.

Table 5*Student perceptions of a traditional methodology (in fields associated with probability and statistics)*

Section	Frequent answers
1. Positive opinions of the methodology used (Traditional)	<ul style="list-style-type: none"> — There is the basis to know how to make graphs and be able to understand them. — In their work, students have come to practice calculating basic parameters such as mode, mean and median. — It is considered useful to be able to quantify the correlation between two variables within the workplace.
2. Details of the methodology used to improve (Traditional)	<ul style="list-style-type: none"> — It is thought that there is a lack of more interaction with more real problems, not so fictitious. — Many students remember very little of what the field was about and have not been able to associate it with their work. — There may be cases closer to reality with difficult statistical calculations supported by friendly digital platforms, including software that makes it possible to optimize times and speed up results. — More dynamic classes, group participation and applying more work based on problem analysis are required. — Class times should be longer, in order to improve learning. — The method applied by older teachers could be improved, doing it in a more dynamic way.

4. DISCUSSION

Encompassing all the quantitative and qualitative results obtained in the research, it can be highlighted that the educational methodology based on Education 4.0 was more effective than the traditional approach and purely online strategies. This is because the four pillars of Education 4.0 take into account the demands of 21st century university students, increasingly faced with the current industry 4.0; On the other hand, the traditional approach presents deficiencies in technological and attitudinal competencies, in addition, online proposals present deficiencies in the development of character and procedural competencies.

Based on the above, it can be said that the results agree with what was previously investigated by various researchers, since the training impact of Education 4.0 is highlighted in experimental studies (Perazzo, 2021), the effectiveness of a methodology based on competencies for the strengthening the understanding of statistical topics (Sánchez & Hoyos, 2008), the effectiveness of methodologies based on the creation of projects for the assimilation of topics associated with descriptive statistics (Vargas et al., 2021), practical cases in which promotes teaching and learning with approaches such as Education 4.0 in the field of engineering in business contexts (Mazo et al., 2022), studies that clearly present active methodologies as more effective than traditional ones, even in master's students (Ortiz & Vilchez, 2020) and other similar studies at an experimental level, in which ICT tools along with collaborative projects are highlighted as preferable for the development of statistical skills (Mesa et al., 2017).

Regarding the specific findings found in the research, it can be said that a proposal to implement Education 4.0 in a blended environment has been fully carried out, not only covering the components of said model, but also with the experimental comparison of its application with other possible methodologies. The previous postulates were applied with satisfactory results that will be presented below.

First, the methodology based on Education 4.0 was compared with the application of an e-learning approach in achieving basic statistical competencies in the use of Power BI software. In the group with e-learning material, the average number of competencies achieved tended to decrease at the end of the research; This decrease in student skills represents a singular point, possibly because the students were now more aware of the breadth of the statistical software in question and the perception of their level with said tool was more rigorous.

In the group with the methodology based on Education 4.0, there was a notable increase in terms of handling the statistical software in question. This was obtained because with the e-learning methodology you basically have the advantages of ICT tools; however, in the proposal delivered, an emphasis was placed on the design of the evaluations with face-to-face activities and training by competencies. Likewise, there was a p value sufficiently small to accept the research hypothesis (Pandis, 2016), in this case, it referred to that "If a methodology based on Education 4.0 is applied, then there will be a higher level of statistical competencies with Power BI than by applying an e-learning methodology."

The other quantitative variable worked on in the research was the level of statistical competencies for scientific research in higher education (having 1 as the minimum possible and 5 the highest level), comparing the group of students with the Education 4.0 methodology and another with traditional methodology. The average obtained in the research group was significantly higher than that in the control group. Both groups had a small standard deviation, a detail that was highlighted in the d -Cohen coefficient, which, due to its relatively high value, represented a large to very large effect size (Sawilowsky, 2009). As a statistical parameter to consider, there is also a p value with a value sufficiently small for what is expected in the research, indicating statistical significance in the difference in means between the two groups (Choi & Kim, 2023).

To encompass the previous observations, the students' perceptions regarding the methodology based on Education 4.0 were presented and compared with the perception of students who have received training based on traditional methodologies. The first has been seen as a methodology well received by students, highlighting positive aspects such as the practical application of knowledge, the dynamism in semester projects and the use of useful software in industry 4.0; There are aspects to improve such as having more class time for such a dynamic class and the difficulty of working students in catching up when they cannot attend, observations that agree with what has been pointed out in other similar studies (Akimov et al., 2023; Oliveira & Saraiva, 2023; Tvenge & Martinsen, 2018).

Likewise, the perceptions of the students who saw the same core content of the subject probability and statistics were taken, but using a methodology typical of the classical school. This approach has had few positive aspects to highlight, such as having a basis for the interpretation of graphs and the calculation of elementary parameters; However, the aspects to improve highlight the lack of problems close to practical applicability in Industry 4.0, the little dynamism, the lack of use of technological tools requested in the workplace and the few or no project-type group activities, being aligned observations. as highlighted in other studies (Almeyda Vázquez et al., 2019; Calle-Suárez & del Rocío Quichimbo-Rosas, 2021; Romani-Romani & Gutiérrez, 2022).

The importance of the previously highlighted findings lies in the fact that a description of a methodology focused on Education 4.0 but adapted to a blended environment has been deployed, research skills have been promoted in students, having more statistical tools to face their degree work. , innovation has been proposed in the curriculum in terms of the inclusion of industry 4.0 software such as Power BI, a contribution has been made to knowledge by comparing different methodologies experimentally and, in short, innovative perspectives have been given for the comprehensive improvement of university education.

Among the limitations found during the research, the difficulty for some students in applying a model as complete as Blended Education 4.0 can be highlighted, since the degree of autonomy required is notably greater than that of a traditional top-down and rote methodology. Likewise, the lack of some laboratory supplies and the repeated absences of groups of student workers who work through rotating shift systems, increased the challenges to be overcome in terms of flexibility on the part of the teacher and responsibility on the part of the students.

The biases found in the research can be summarized in the sample being taken only from students in the evening hours, mostly comprising hard-working adult students with certain character competencies already formed through experience. Likewise, as an exception found in the data collected, there is a decrease in the percentage of skills worked on by students who were able to learn using e-learning tools, which could be due to an awareness of the students and a more realistic and complete perception. of their own skills using software as important and complete as Power BI.

As a suggestion for new studies based on the results previously presented, it is proposed to include more variables such as the motivation of the students in response to the different proposed strategies. It is also recommended that the main variable not be the simple increase in overall academic performance, since one may fall into the bias of designing methodologies with inadequately simple difficulty indices (Cárdenas Ayala, 2013). Also, continuous improvement is prudent in terms of the strategies of each semester, promoting not only the creation of knowledge by a leading student, but with more activities that promote service to the community and complement character competencies, these being a valuable strength in the face of growing technological evolution and a differentiating element for future professionals.

5. CONCLUSION

Finally, it can be concluded that Education 4.0 has been satisfactorily applied in the field of university training, adapting its requirements to a blended system and taking the benefits of an innovative approach, oriented to the solution of real problems of professionals adapted to industry 4.0.

The percentage of statistical competencies with the Power BI software when a methodology like the previous one is used is visibly higher than when an e-learning strategy is used, since although the benefits of technology are available in tutorials and ICT tools, it is necessary to complement with a dynamic class, problem solving in groups and formal evaluation in person.

The level of statistical competencies applied to the research was also higher in the methodology based on Education 4.0, when comparing the level reported by students who received training based on the traditional school, highlighting the importance of innovating in educational strategies by adding learning oriented towards the real application of knowledge, the possibility of using technological tools in group projects and the creation of conditions so that the student is the true active protagonist in the training process. It should be noted that these observations have been satisfactorily reinforced by the qualitative perception of the students.

As a suggestion for future studies linked to the previously presented results, it is proposed to study the effectiveness of different methodologies in the development of skills for industry 4.0 such as the use of Tableau and SAP software, in addition to personnel management in small projects that require planning, problem solving and teamwork. Furthermore, the Education 4.0 methodology can be complemented with Learning and Service proposals, involving the student more with the community, creating spaces for the development of character competencies and promoting the training of more complete and comprehensive professionals, being a fundamental pillar in the sustainable growth of our society.

Agradecimientos / Acknowledgments:

I express my gratitude to the students, teachers, and authorities of the University of Aconcagua – Chile, and especially to Alonso Tucas, Marcela Pachao, Geraldine Torres and Christian Cavour, for their support in carrying out this research.

Conflicto de intereses / Competing interests:

The author declares that he does not include any conflicts of interest.

Rol de los autores / Authors Roles:

Does not apply.

Fuentes de financiamiento / Funding:

The author declares that he did not receive specific funding for this research.

Aspectos éticos / legales; Ethics / legals:

The author declares that he has not incurred in unethical aspects, nor has he omitted legal aspects in carrying out the research.

REFERENCES

- Akimov, N., Kurmanov, N., Uskelenova, A., Aidargaliyeva, N., Mukhiyayeva, D., Rakhimova, S., Raimbekov, B., & Utegenova, Z. (2023). Components of education 4.0 in open innovation competence frameworks: Systematic review. *Journal of Open Innovation: Technology, Market, and Complexity*, 9(2), 100037. <https://doi.org/https://doi.org/10.1016/j.joitmc.2023.100037>
- Almeyda Vázquez, A., Otero Solis, D., & García Cabezas, A. (2019). Formación de competencias de investigación en la Facultad de Psicología de la Universidad de la Habana. Su evolución a través de diferentes planes de estudio. *Katharsis: Revista de Ciencias Social*, 27, 102-114. <https://dialnet.unirioja.es/servlet/articulo?codigo=7143376>
- Arias Gonzáles, J. L., & Covinos Gallardo, M. (2021). Diseño y metodología de la investigación. *Enfoques Consulting EIRL*, 1, 66–78.
- Asunción, S. (2019). Metodologías Activas: Herramientas para el empoderamiento docente. *Revista Docentes 2.0*, 7(1), 65–80.
- Bastar, S. G. (2019). *Metodología de la investigación*. Red Tercer Milenio
- Calle-Suárez, C. A., & del Rocío Quichimbo-Rosas, A. (2021). Presencia de metodologías tradicionales en la educación del Ecuador. *Dominio de Las Ciencias*, 7(4), 1205–1215.
- Cárdenas Ayala, A. (2013). Índice de dificultad y asimetría de los ítems en las pruebas pedagógicas. *Horizonte de La Ciencia*, 3(5), 65. <https://doi.org/10.26490/uncp.horizonteciencia.2013.5.77>

- Choi, W., & Kim, I. (2023). Averaging p-values under exchangeability. *Statistics & Probability Letters*, 194, 109748. <https://doi.org/https://doi.org/10.1016/j.spl.2022.109748>
- Ciolacu, M. I., Mihailescu, B., Rachbauer, T., Hansen, C., Amza, C. G., & Svasta, P. (2023). Fostering Engineering Education 4.0 Paradigm Facing the Pandemic and VUCA World. *Procedia Computer Science*, 217, 177–186. <https://doi.org/https://doi.org/10.1016/j.procs.2022.12.213>
- Ciolacu, M. I., & Svasta, P. (2021). Education 4.0: AI empowers smart blended learning process with Biofeedback. *2021 IEEE Global Engineering Education Conference (EDUCON)*, 1443–1448.
- Ciolacu, M. I., Svasta, P., Hartl, D., & Görzen, S. (2020). Education 4.0: smart blended learning assisted by artificial intelligence, biofeedback and sensors. *2020 International Symposium on Electronics and Telecommunications (ISETC)*, 1–4.
- Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Academic press.
- Gagné, M., Hamel, C., Lauzier, S., Penney, S.-E., Bourbeau, J., Moisan, J., & Boulet, L.-P. (2021). Comparative educational outcomes of an active versus passive learning continuing professional development activity on self-management support for respiratory educators: A non-randomized controlled mixed-methods study. *Nurse Education in Practice*, 57, 103256. <https://doi.org/https://doi.org/10.1016/j.nepr.2021.103256>
- Hernández-Sampieri, R., & Mendoza, C. (2020). *Metodología de la investigación: las rutas cuantitativa, cualitativa y mixta*. Editorial McGraw-Hill Education.
- Hmoud, H., Al-Adwan, A. S., Horani, O., Yaseen, H., & Zoubi, J. Z. Al. (2023). Factors influencing business intelligence adoption by higher education institutions. *Journal of Open Innovation: Technology, Market, and Complexity*, 9(3), 100111. <https://doi.org/https://doi.org/10.1016/j.joitmc.2023.100111>
- Kim, T. K. (2015). T test as a parametric statistic. *Korean Journal of Anesthesiology*, 68(6), 540–546.
- Labori, J. (2023). Índice de dificultad y aprendizaje activo en Educación 4.0 aplicada a formación universitaria. *Revista Innova Educación*, 5(3), 129–144.
- March, A. F. (2006). Metodologías activas para la formación de competencias. *Educatio Siglo XXI*, 24, 35–56.
- Martinez-Garcia, A., Horrach-Rosselló, P., & Mulet-Forteza, C. (2023). Evolution and current state of research into E-learning. *Heliyon*, 9(10), e21016. <https://doi.org/https://doi.org/10.1016/j.heliyon.2023.e21016>
- Mazo, W. A., Manrique, J. F. N., & Nieto, L. Á. P. (13-16 setiembre de 2022). *Experiencia en la enseñanza y el aprendizaje de la inteligencia de negocios en un programa de ingeniería de sistemas usando como estrategia didáctica el proyecto integrador* [Ponencia]. *Encuentro Internacional de Educación en Ingeniería*. <https://doi.org/10.26507/paper.2680>
- Mesa, M. B., Morales, F. H. F., & Duarte, J. E. (2017). Aprendizaje basado en proyectos colaborativos mediados por TIC para el desarrollo de competencias en estadística. *Saber, Ciencia y Libertad*, 12(2), 220–232.
- Muawiyah, D., Yamtinah, S., & Indriyanti, N. Y. (2018). Higher education 4.0: assessment on environmental chemistry course in blended learning design. *Journal of Physics: Conference Series*, 1097(1), 12058.
- Oliveira, S. R. M., & Saraiva, M. A. (2023). Leader skills interpreted in the lens of education 4.0. *Procedia Computer Science*, 217, 1296–1304. <https://doi.org/https://doi.org/10.1016/j.procs.2022.12.327>

- Ortiz, J. Á. R., & Vilchez, J. (2020). Método clase invertida y desarrollo de competencias estadísticas en estudiantes de maestría. *Revista EDUCARE-UPEL-IPB-Segunda Nueva Etapa 2.0*, 24(3), 159–182.
- Oviedo, H. C., & Campo-Arias, A. (2005). Aproximación al uso del coeficiente alfa de Cronbach. *Revista Colombiana de Psiquiatría*, 34(4), 572–580.
- Özköse, H., & Güney, G. (2023). The effects of industry 4.0 on productivity: A scientific mapping study. *Technology in Society*, 75, 102368. <https://doi.org/https://doi.org/10.1016/j.techsoc.2023.102368>
- Pandis, N. (2016). The chi-square test. *American Journal of Orthodontics and Dentofacial Orthopedics*, 150(5), 898–899.
- Perazzo, D. (2021). La educación 4.0 y su impacto en la formación docente y en el aprendizaje de los alumnos. *Convergence Tech*, 5(5), 47–52.
- Raman, A., & Rathakrishnan, M. (2019). Blended Learning in Higher Education 4.0: A Brief Review. *Redesigning Higher Education Initiatives for Industry 4.0*, 70–84.
- Regmi, K., & Jones, L. (2020). A systematic review of the factors—enablers and barriers—affecting e-learning in health sciences education. *BMC Medical Education*, 20(1), 1–18.
- Rendón-Macías, M. E., Zarco-Villavicencio, I. S., & Villasís-Keever, M. Á. (2021). Métodos estadísticos para el análisis del tamaño del efecto. *Revista Alergia México*, 68(2), 128–136.
- Romaní-Romaní, F., & Gutiérrez, C. (2022). Experiencia, actitudes y percepciones hacia la investigación científica en estudiantes de Medicina en el contexto de una estrategia curricular de formación de competencias para investigación. *Educación Médica*, 23(3), 100745. <https://doi.org/https://doi.org/10.1016/j.edumed.2022.100745>
- Ruano, P. C., Martínez, S. G., Valero, A. F., & Martínez, J. T. (2021). Análisis comparativo de los perfiles motivacionales y el Estado de Flow entre una metodología tradicional y la metodología Flipped Classroom en estudiantes de Educación Física. *Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación*, 39, 338–344.
- Sánchez, E., & Hoyos, V. (2008). *La estadística y la propuesta de un currículo por competencias*. En A. Salcedo, Educación Estadística en América Latina: Tendencia y perspectivas (pp. 2014–227). Universidad Central de Venezuela
- Sawilowsky, S. S. (2009). New effect size rules of thumb. *Journal of Modern Applied Statistical Methods*, 8(2), 26.
- Stek, K. (2022). *Personality Development in Higher Education in the Era of Industry 4.0: Comparing educational practices and philosophies in Industry 1.0 and Industry 4.0*. En Smart Industry—Better Management (pp. 35–50). Emerald Publishing Limited.
- Tvenge, N., & Martinsen, K. (2018). Integration of digital learning in industry 4.0. *Procedia Manufacturing*, 23, 261–266. <https://doi.org/https://doi.org/10.1016/j.promfg.2018.04.027>
- Vargas, J. D., Arregocés, I. C., Solano, A. D., & Peña, K. K. (2021). Aprendizaje basado en proyectos soportado en un diseño tecno-pedagógico para la enseñanza de la estadística descriptiva. *Formación Universitaria*, 14(6), 77–86.

- Vásquez, R. A. D., Espinoza, J. L. A., & Cabrera, M. A. C. (2022). Power bi como herramienta de apoyo a la toma de decisiones. *Universidad y Sociedad*, 14(S3), 195–207.
- Velandia Mesa, C., Serrano Pastor, F. J., & Martínez Segura, M. J. (2019). The challenge of competencies in training for educational research: a conceptual approach. *Actualidades Investigativas en Educación*, 19(3), 310–339.
- Zúñiga, P. I. V., Cedeño, R. J. C., & Palacios, I. A. M. (2023). Metodología de la investigación científica: guía práctica. *Ciencia Latina Revista Científica Multidisciplinar*, 7(4), 9723–9762.

