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Challenge-based learning and design thinking in higher education: institutional strategies for linking experiential learning, innovation, and academic performance

Samara Romero Caballero [ID][a], Liliana Canquiz Rincón [ID][a], Andrés Rodríguez Toscano [ID][b], Alejandro Valencia Pérez [ID][a] and Gloria Moreno Gómez[c]

[a]Department of Humanities, Universidad de la Costa CUC, Barranquilla, Colombia; [b]Energy Department, Universidad de la Costa CUC, Barranquilla, Colombia; [c]Academic Vice-Rector, Universidad de la Costa CUC, Barranquilla, Colombia

ABSTRACT

This research describes the results of the implementation of the Challenge Based Learning (CBL) with the Design Thinking (DT) methodology, evaluating its stages for the co-creation of solutions to challenges in business contexts combined with an innovative institutional strategy in the higher education. This methodology, articulated with the CBL strategy at the Universidad de la Costa Barranquilla Colombia, facilitates the technological development, research and innovation products, achieving learning results and generic competencies stipulated in the subjects, regardless of the profession the student is pursuing. The results show the concentration of pedagogical and didactic strategies due to their effectiveness in achieving the learning results of the subjects, obtaining the solution to the challenge and associated products. Finally, the test results of students' generic competencies improve by 55% when compared to previous periods where the strategy was not executed, contributing with products that have a favourable impact on the social environment.

Introduction

Currently, higher education institutions (HEIs) develop new learning strategies that seek to improve academic performance and student training from their skills (Felipe et al., 2020; Shafiq & Parveen, 2023). Some institutions have proposed to redirect the training of students to meet the requirements of the labour market at a national and international level, considering globalisation and technological progress with the development of pedagogical approaches supported by innovative methodologies (Latorre et al., 2019; Malik et al., 2023; Marra, 2022; Sánchez et al., 2018). These requirements involve a constant update of the curricula, a modification of the role of students and teachers, collaboration with other actors (Bhat et al., 2020; Bringle & Clayton, 2023; L. A. D. Rodríguez et al., 2020) and the development

of new generic skills associated with the practice of the profession. Even so, most students continue to have difficulties applying what they have learned to the work context and express the need for new teaching methods or methodologies that improve said learning and its relevance in the business sector (Felipe et al., 2020; González et al., 2020).

In Europe, various investigations conclude that students in HEIs should be prepared to use the learning experiences of their training in relevant environments, so that when they finish their professional career, they are able to contextualise, remember and correctly apply the knowledge acquired and the new knowledge to be acquired in the work environment (Casanova et al., 2019; Richmond et al., 2021; Zlatkin et al., 2023). In this sense, HEIs must work on pedagogical approaches that develop active, experiential, and experiential learning to strengthen performance in the work environment, with innovative pedagogical strategies that are connected to learning outcomes, the required generic competencies, and products that allow evidence of their development and impact on the social environment (M. M. B. Álvarez & Asensio, 2020; D. F. López et al., 2020; Marra, 2022).

These generic skills are required to address challenges, achieve goals, work collaboratively with different actors, the use of technologies and an understanding of the long-term effects of proposed solutions, with the integration of disciplinary knowledge in the work context. In this regard, some investigations have implemented challenge-based learning (ABR) as a pedagogical approach (L. A. F. López et al., 2021) and have identified the need to establish methodologies that facilitate the development of solutions to challenges, and adapt to current curricular models, that ensure learning effectively (Bustos et al., 2019; L. A. F. López et al., 2021). The ABR as a pedagogical approach does not establish by itself tools and techniques that facilitate the solution of challenges from the training of the profession, but it tends to show findings and/or products that can be easily associated with the learning results. This opens the way to the development of motivating methodologies, techniques and tools, strategically articulated with the ABR to demonstrate the learning results, in a relevant environment with continuous and permanent evaluation processes during training (Priede et al., 2019).

Due to the pandemic generated by COVID-19 (Wagiran et al., 2022), the business sector has given greater priority and relevance to generic skills and the use of digital tools in the work context (Abidi et al., 2023; Wagiran et al., 2022). Therefore, the assurance of learning generates an important discussion in the field of education and pedagogy related to classroom management and didactic strategies for the mediation between knowledge and the development of competencies (Guevara, 2021). This implies a deeper understanding of these practices that allows focusing attention on improving student learning, with theoretical guidelines, learning environments, the roles of the actors in the educational process, among other fundamental aspects (Ibarra et al., 2022). However, there are few investigations in higher education that show a follow-up in the learning results articulated to the active methodologies, didactic strategies with said pedagogical approach in the HEIs (Latorre et al., 2019).

Consequently, higher education demands an articulated work with the labour context, integrating the academy with the business sector and universalising the learning process from the generic competences as determinants in the global/local change and the learning results as evidence that it learned is useful to society. In this way, students have a great receptivity to activities when they are directly immersed in a context, with

great educational experiences and practical activities (Malmqvist et al., 2015; Ochoa et al., 2021).

In Asia and Oceania, different investigations have also delved into this context, with the concern to find alternative methodologies that develop generic competences to favour the speed and precision of learning, towards the development of creativity for solving challenges and problems during student training (Bhat et al., 2020; Hamidi et al., 2011). However, it stands out that there is still a need to deepen the assurance of meaningful and lasting learning in higher education students.

In addition to the above, in the specialised literature the use of agile methodologies such as design thinking has been highlighted, which favours the ideation and prototyping of innovative solutions to real problems worked from the subjects. This methodology has a high potential to demonstrate learning outcomes in relevant environments or in a work context (Gutiérrez, 2019; Ho & Chng, 2021). However, the solid articulation with the generic competences is not yet evident, in the dynamics of evaluation of the learning results of the HEIs with the ABR pedagogical approach considering, feedback aspects and continuous improvement of the teaching-learning process (P. R. Álvarez-Pérez & López-Aguilar, 2018; Bhatti et al., 2022).

In Latin America, there is also a need in higher education to incorporate active methodologies in the teaching-learning process to enhance components such as motivation, the classroom environment, meaningful learning and effectively develop generic skills that also favour the connection and performance of students in the labour sector, which is essential for the social and economic development of most of the countries that comprise it (Flores, 2020). These components that interact in the training process led to the use of strategies and approaches towards the functionality and applicability of learning in different work contexts.

On the other hand, from the analysis of pedagogical theories, there are investigations that have identified potentialities and difficulties in the didactic for its rigorous application based on the curricula (Akuma & Callaghan, 2023). Even so, the gap Is this correct? persists between the skills developed during the training of students and the skills they apply during the exercise of their profession (Torres et al., 2017).

Some higher education institutions in Latin America have used the CBL and have made updates to their curricula to reduce this gap (Tecnológico de Monterrey, 2015), but, it is a task that depends on many factors that they do not have full control of or that they have not adequately managed, such as motivation, practical learning, interaction during the training process with employers, learning environments, the teaching methodology, didactic resources, among others (Aguilera et al., 2010); which implies the need to build a constructive and strategic alignment (Crites & Rye, 2020). Therefore, the objective of this research is to evaluate the effect of the development of Challenge-Based Learning, Design thinking, pedagogical strategies and the active assessment of challenges continuously during the training process in the deepening subjects of the last cycle of study, on the generic competences and the results and/or products obtained.

Methodology

The methodology implemented in this study is shown in Figure 1. This flowchart shows the institutional strategy used for the use and analysis of challenge-based learning

articulated with design thinking considering the products of technological development and innovation (DTI), with respect to generic competencies.

As shown in Figure 1, the research methodology is developed in three phases: during the training process, at the end of the training process in the subjects and at the end of the evaluation of the generic competencies declared in them.

During the training process, the VAR is applied to the students and feedback is given to the tutor.

At the end of the training process in the subjects, the analysis of performance in learning results by academic period is developed, as well as the teaching evaluation, and the research projects, development products and technological innovation (DTI). Additionally, the strategies used by tutors in class are considered to identify the adaptation of the same and their effect.

In the analysis of the strategies used by the tutor in the classroom per period, the use of the pedagogical strategies implemented is evaluated through a Pareto diagram. Each tutor implements the strategies with which he feels most comfortable or effective according to the content of the subject and the needs of the student. This Pareto is a mechanism that articulates teaching practice with the pedagogical strategies most used in the specific context of the subject.

Pareto is used in different investigations to prioritise and adjust the focus of actions and strategies in different disciplines (A. T. Rodríguez et al., 2021).

Subsequently, an analysis of the performance of the learning results is proposed, associated with the stages of Design Thinking through a box diagram and articulated with the pedagogical strategies.

At the end of the evaluation of the generic competencies declared in the subjects, the evaluation of generic competencies is applied and an analysis of this is carried out. In the analysis, the information from the previous phases is crossed through a hermeneutic triangulation, as Cisterna (2005) calls it, which includes gathering and dialectically crossing all the information pertinent to the object of study in its context and that emerged in the research, and that It essentially constitutes the corpus of its results, which in turn is triangulated with the
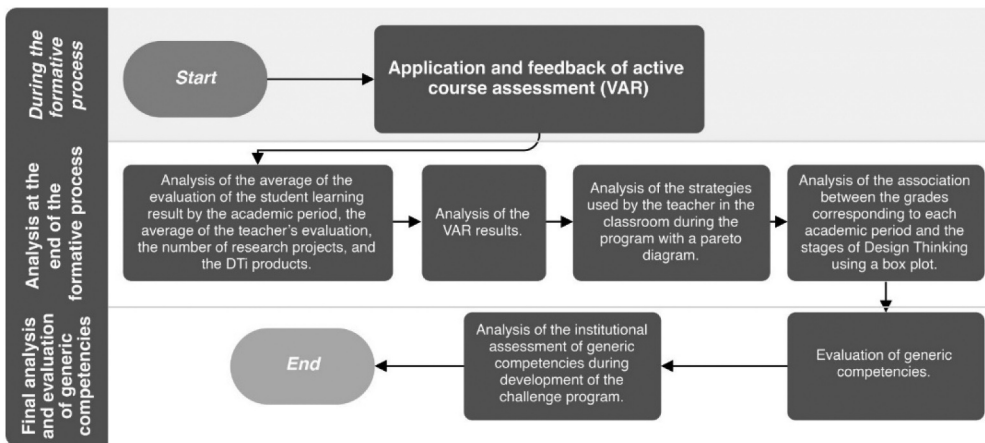
Figure 1. Study methodology flowchart.

information of the theoretical referential framework. In this phase, the results are compared in the academic periods where the strategy was applied and in the periods where it was not applied.

These analyzes respond to a mixed study with a dominant status towards the quantitative and concurrent type, since the data is processed and analysed simultaneously, which allows constant feedback to them and thus obtain relevant information relationships with interpretations also from the qualitative (Johnson & Onwuegbuzie, 2004).

The higher education institution studied is the Universidad de la Costa. This university has more than 12,000 students and is in the Caribbean Region, north of Colombia. For this research, ethical approval from the university was provided. The subject of study is students who undertake deepening electives in the third cycle. A total of 143 deepening electives were considered between 2020 and 2022. The number of students who participated in the study was 5186 (100% of students), and the number of teachers was 195 during the academic periods 2020–1, 2020–2, 2021–1, 2021–2, and 2022–1 (six months each). The pedagogical strategies implemented on the courses were workshops, presentations, case study, round table, diagram and concept map, video forums, focus groups, conversations, brainstorming, benchmark, essay, storyboard, cause-effect diagram, discussion table, LEGO®, simulation, Ishikawa diagram, pitch, instrument guides, Delphis method, brainwriting, and the six thinking hats.

The activities developed with these strategies are evaluated with a process that includes multiple forms of measuring student performance, taking into account their abilities, skills, motivation and attitudes. In Colombia, undergraduate programmes are established in a time frame of four to five years to be completed (MINISTERIO/SNIES). At the Universidad de la Costa, the undergraduate academic programmes are divided into three cycles: the basic cycle (first year), the professional cycle (second year) and the deepening cycle (final year). In the third cycle, deepening electives (mandatory) are part of Challenges Unicosta. The basic cycle consists of the first 2 years of education, the professional cycle is between the third and fourth year and the deepening cycle goes from fourth to fifth year, explained and expanded in the Curricular model of the Institution. The courses to be evaluated correspond to the undergraduate programmes taught at the Universidad de la Costa: Architecture, Systems Engineering, Electronic Engineering, Health Services Administration, Business Administration, Banking and Finance, Public Accounting, Finance and International Relations, Marketing and advertising, International business, Science, Psychology, Environmental administration, Environmental engineering, Civil engineering, Law, Electrical engineering, Social communication and Digital media, Bachelor's degree in primary education, Agroindustrial engineering, and industrial engineering. The generic competencies considered for the study were Quantitative Reasoning, Reading, Writing, Citizenship and English, which are developed on a setting emulating the professional context.

The Challenge-Based Learning (CBL) at universidad de la costa

Challenge-Based Learning (CBL) is a pedagogical approach that actively involves the student in a real-life situation (relevant and linked to the business environment) that implies the definition of a challenge and the implementation of a solution. It focuses on the acquisition of new knowledge and the development of soft skills and abilities from

facing the challenge (Tecnológico de Monterrey, 2015). In Universidad de la Costa, the satisfaction of the construction and the development of students' skills are monitored, in the different stages of the methodology, to apply timely improvement actions; as can be seen in Table 1.

This pedagogical approach is part of the so-called experiential learning, a holistic and integrated approach to learning that combines experience, cognition, and behaviour (Tecnológico de Monterrey, 2018). In the case of the CBL, students are stimulated because they face real challenges, led not only by their teachers, but also by people from the external sector (employers) who collaborate in the classroom dynamics to improve the capacities of the students (L. A. F. López et al., 2021).

Challenge based learning provides a student-centred learning space that recreates the experiences of a modern workplace (Santos et al., 2015). This is how the CBL stimulates the expectations and interests of students in their search for practical meaning in education, while they develop key competencies such as collaborative work, decision-making, assertive communication, ethics and leadership (Malmqvist et al., 2015).

Figure 2 shows the development of the Unicosta Challenges programme considering the stages of the DT methodology, pedagogical activities and the institutional strategy.

The students solve the challenges with the guidance of the tutor. Likewise, business professionals participate in the process in each stage of the DT, contextualising the challenges and providing feedback on the solutions. For each academic period, we work collaboratively with 40 companies (schools, universities, foundations, industrial plants, maintenance companies, power generators, government entities, innovation centres, water, gas, and electricity service companies,

Table 1. Aspects assessed by the VAR.

| Assessment moment 1: empathize and define	Assessment moment 2: Ideate and prototype	Assessment moment 3: test and assess
Communication and contact with the company (external agent); approach and knowledge of the open challenge.	Generation of ideas freely, stimulated by the tutor.	Feedback from the tutor on the prototypes or solutions to the work teams
Characterization and detailed knowledge of the company or the open challenge.	Collaborative work of students in teams, for the generation of ideas.	Evaluation made by the tutor to the solutions or prototypes presented by the students
Presence of the employer in the classroom or a clear explanation of the open challenge by the teacher.	Creativity and innovation in the generation of ideas	Advice and support, by the tutor, to the work teams for the final presentation of the solution.
Knowledge of the challenge to solve	Motivation and strategies of the tutor (teacher) for the generation of ideas	Motivation and strategies of the tutor (teacher) to give concrete form to the ideas and evaluate them (Prototyping and testing)
Motivation and strategies of the tutor (teacher)	Student engagement in challenge work	Student engagement in challenge work
Student engagement in challenge work	Development of the content of the subject in the second assessment moment articulated to the development of the challenge	Development of the content of the subject in the third assessment moment cut articulated to the development of the challenge
Development of the content of the subject in the first moment of assessment articulated to the development of the challenge	Generation of ideas freely, stimulated by the tutor.	Feedback from the tutor on the prototypes or solutions to the work teams
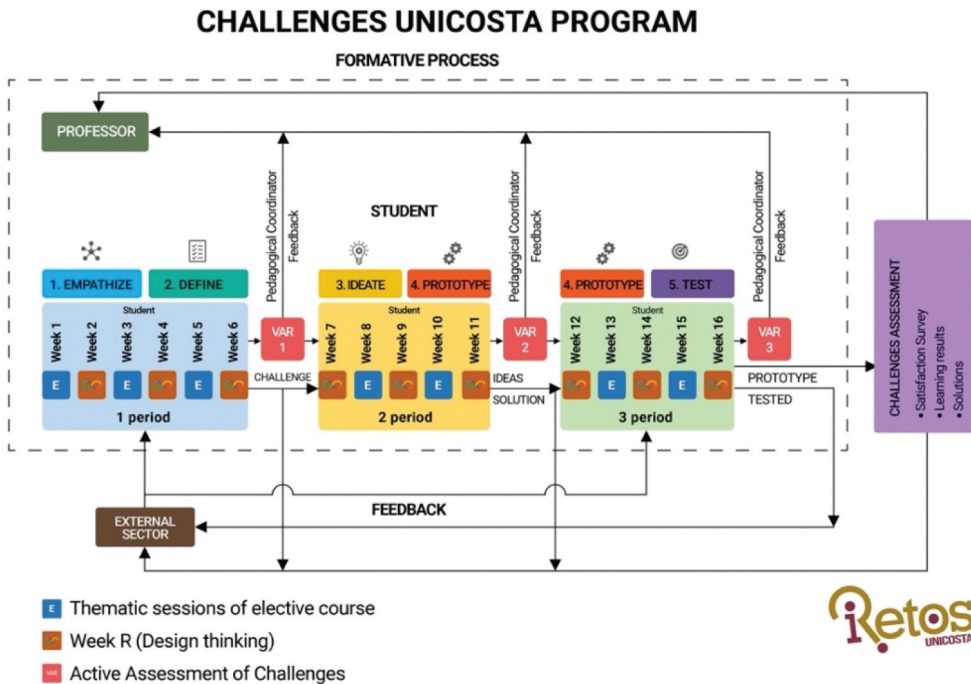
Figure 2. Challenges unicosta program.

etc.). The challenges are solved according to the skills to be developed, the learning results and the academic performance indicators declared in the subject. See the following example (Figure 3) describing how the Challenges Unicosta Program relates to the external stakeholders.

The design thinking

Design thinking is a methodology to generate innovative ideas that focus its effectiveness on understanding and solving the real needs of users. Its definition comes from how products work. Hence its name, which in Spanish translates as 'design of thinking', although it is commonly referred to as 'The way designers think' (Rosas et al., 2018). Teachers implement challenge-based learning using the Design thinking methodology, according to the stages described in Figure 2. These stages of Design thinking are associated with academic cuts. In each one of them, the application and feedback of the VAR (Active Assessment of Challenges) are carried out. Ultimately, the academic performance and the development of generic competencies are analysed with the products and results of learning.

To evaluate the process at each stage, the teacher uses techniques and instruments from the Challenge Tool Kit, which contains didactic strategies for each of the stages of the DT methodology and was developed within the framework of this programme for its didactic development, where Permanent feedback of the process
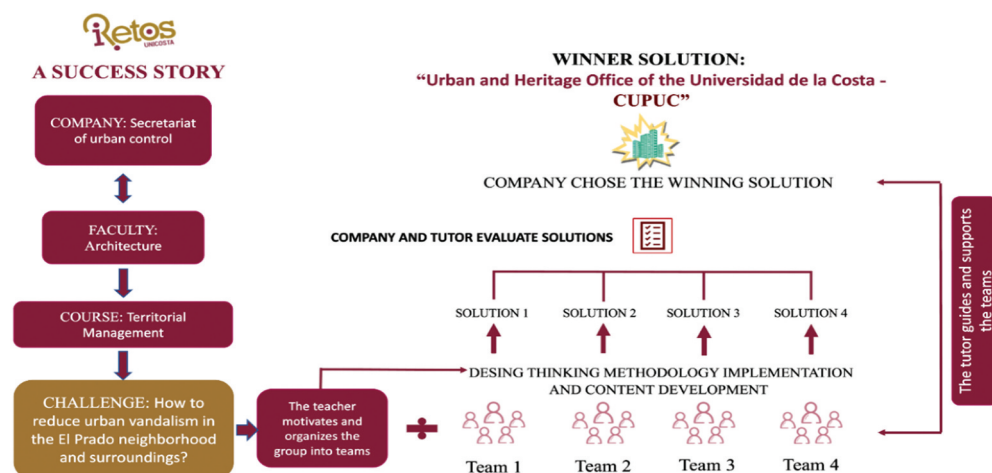
Figure 3. A success story.

prevails from the formative evaluation and the partial and final evaluation as summative evaluation.

### The active assessment of challenges

The VAR (Active Assessment of Challenges) is a tool created at Universidad de la Costa to accompany the development of Challenge-Based learning in the classroom with the Design thinking methodology. The tool is applied to students that participate in the Challenges Unicosta programme in each academic period to monitor the leadership of the tutor and thus, be able to apply improvements in different stages of the methodology. This tool is a questionnaire that, using a Likert scale, measures the development of the programme on each academic period, with questions that respond to each of the design stages, and delves into the following aspects:

The VAR is applied at the end of each stage of the methodology according to Figure 2 and provides valuable information for the continuous improvement of the process.

Results

To start the results section, it begins with Figure 4 which shows the behaviour of the average evaluation of student learning results, the average evaluation of teachers, the number of research projects, DTi products, N° Students/N° tutors and N° solutions/N° students per academic period.

Results show an average rate of growth that learning assessment experiences regarding the N° solutions/N° students and the teacher evaluation in the academic periods 2019–2 and 2020–1. This result is associated with the insertion of challenge-based learning in the courses, showing a significant impact on the average of the evaluation of learning results with a high ratio among the relation N° solutions/N° students. However, DTi products and research projects did not increase because the tutors were experimenting and adapting to the tools,
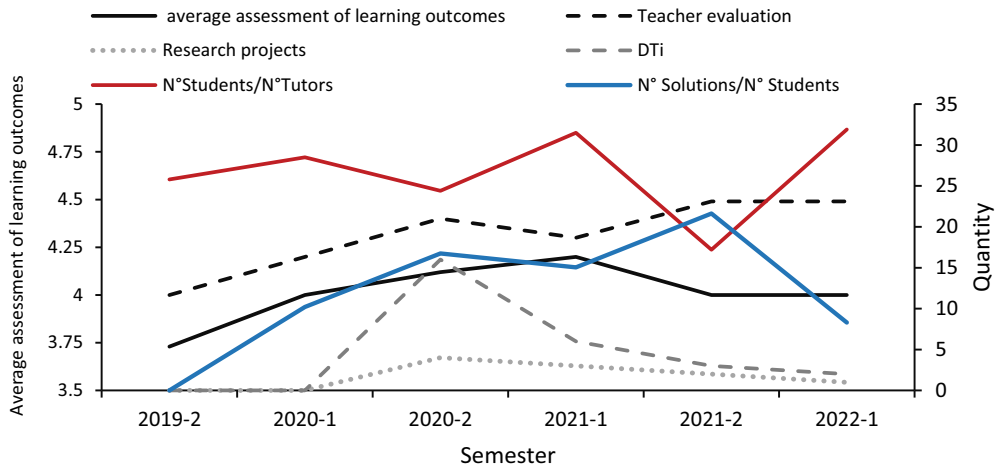
Figure 4. Behavior of the average evaluation of student learning results, the average teacher evaluation, the number of research projects, DTi products, N° students/N° tutors and N° solutions/N° students by academic period.

techniques and new strategies of the toolkits for implementing of the design thinking methodology. This is confirmed by previous research indicating that combining CBL and DT can lead to effective articulation between learning, innovation and research outcomes.

In the 2020–2 academic period, even though the ratio of N° Students/N° tutors decreased, the tutors improved their teaching skills with the techniques of the toolkits and advice from the Challenge programme team. According to the interviews, the tutors selected the techniques and tools that had the greatest impact on the learning results, articulating them with DTi products and research projects since they encourage collaboration and the generation of ideas, which can be essential for solving complex problems and identifying research opportunities. In addition, they allow visualising and organising the ideas and connections between them, which can help identify important patterns and relationships in research projects (Gleason & Rubio, 2020). In the same way, they help students clarify their research objectives and establish an effective action plan.

Between the 2021–1 and 2022–1 academic periods, the number of research projects and DTi products decreased because the type of solutions presented by the students focused more on solving intangible challenges, particularly because of the onboarding of new tutors and the economic crisis in the business sector generated by the COVID-19 pandemic which was yet to be recovered.

Figure 5 shows the results of the VAR applied to the students to evaluate the teacher's management in the development of the Challenges strategy and its methodology on each course.

The results show the positive evolution of the results between the periods 2021–1 and 2022–1, which indicates that in each academic period and according to the stage of design thinking, teachers use relevant strategies to achieve the scope of the stage and guarantee the assurance of learning; however, the decrease in 2022–1 May respond to the
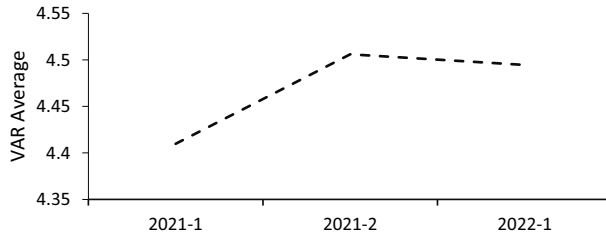
Figure 5. VAR behaviour by academic semester.

return to face-to-face classes, in which teachers were in the need to readapt their strategies to the face-to-face scenario.

Generally, feedback is essential for teachers because it significantly impacts their performance and professional development, improving confidence and motivation, teaching effectiveness, professional development, relationships with students and colleagues, teamwork, and the overall school environment. In summary, feedback is important for teachers' management since it can positively impact their performance and professional development, as well as the effectiveness of teaching (Bellibaş & Gümüş, 2023).

Figure 6 shows the didactic strategies, techniques and tools used by the tutors in all the academic periods of the Challenges programme at Universidad de la Costa CUC – Unicosta
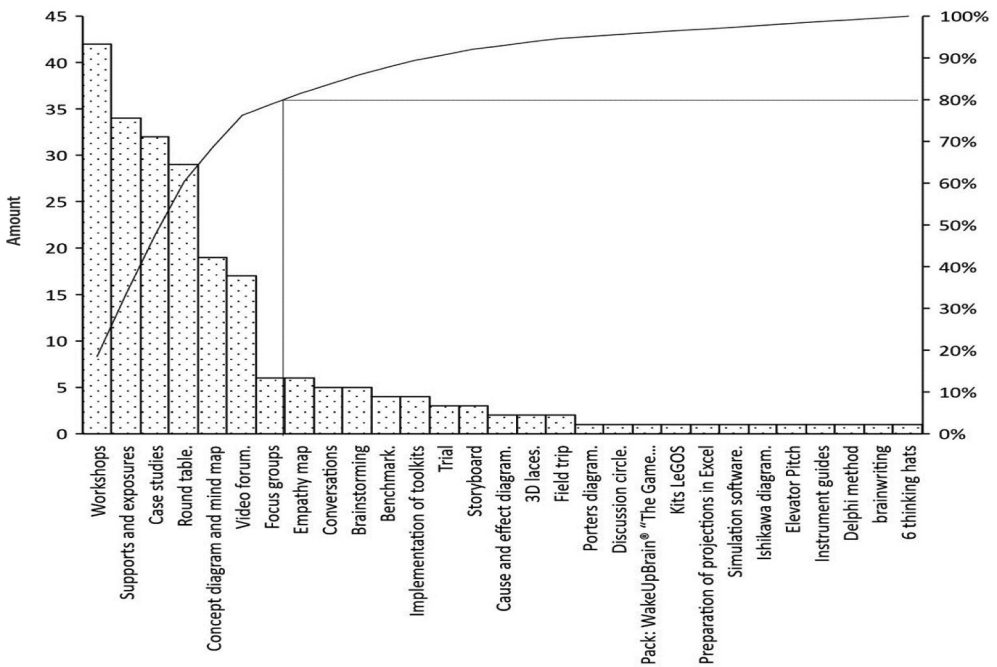

Figure 6. Pareto diagram of the didactic strategies, techniques and tools used by the tutors in the challenges unicosta program.

Results show that 80% of the tutors use 20% of the didactic strategies, techniques and tools available on the toolkits and syllabus. The most used didactic strategies, techniques and tools were workshops, presentations, case studies, round tables, conceptual schemes and maps, video forums and focus groups. All these strategies are complementary to the Design thinking methodology. The courses with the best average in the evaluation of the learning results and DTi projects used the workshops scheme and conceptual map, Storyboard, video forums and round tables. In these, it is highlighted that the tutor had an excellent relationship with the students and assertive communication, maintaining constant motivation in the student through words and gestures.

This type of didactic strategy can develop the students' skills since they allow them to learn and practice in a safe and collaborative environment, developing skills to present information clearly and effectively and improving their confidence and communication skills. In the same way, strategies allow students to show what they have learned and improve their ability to transmit ideas and knowledge to others. In addition, they contribute to the development of student's ability to analyse complex situations, apply theoretical knowledge and solve problems. They also encourage dialogue and discussion among students, which helps them learn to listen and consider different perspectives. They help students organise and comprehend information more effectively, and see and hear experts on a subject, which enhances their understanding and learning, encourages collaboration and discussion among them, and helps them deepen their knowledge and develop Social and communication skills. Finally, by actively participating in the learning process, students can develop critical skills, solve problems, communicate effectively, and expand their understanding of a topic (Freeman et al., 2014).

Figure 7 shows a box and whisker plot of the average assessment of student learning outcomes according to the stages of design thinking.

In the stage of empathising and defining, it is possible to identify some aspects that are relevant: the first is related to the height of the box (shaded region in Figure 7), which was
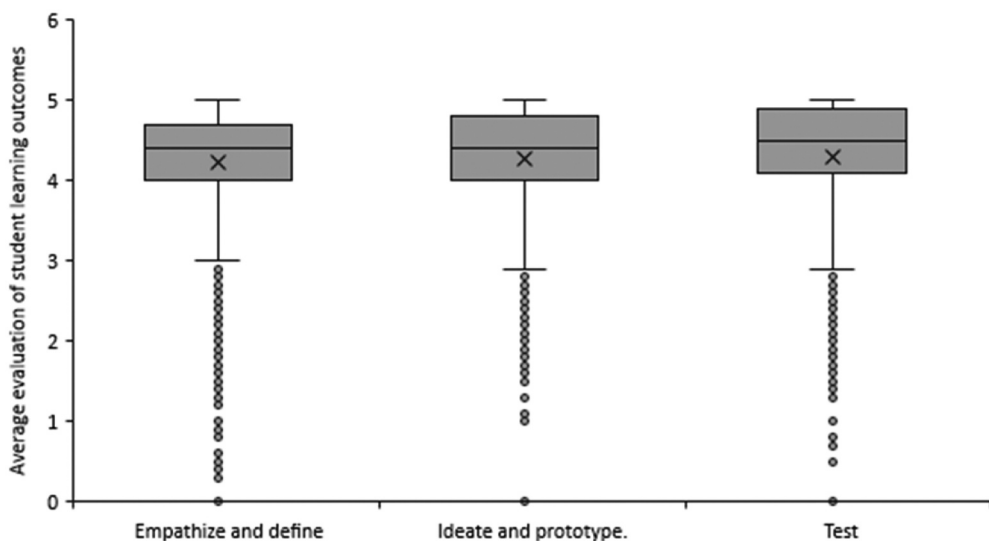

Figure 7. Box plot associated with the corresponding grades for each academic period and stage.

smaller for the stage of empathising and defining; confirming the high homogeneity of the grades obtained by the students. This same consideration varies for evaluation moment 2, during the ideation and prototyping stage, and evaluation moment 3, the testing and evaluation stage, where a greater length is observed in the box of the diagram. On the other hand, for evaluation moment 2 (devise and prototype) a smaller number of atypical data is observed (circular points below the moustache), which suggests classroom management by the tutor, with more uniform effects in all the students who participate in the strategy. Another aspect that is evident in Figure 7 corresponds to the median (the horizontal line that divides the box); this value is observed above in moment 3, which suggests better performance in the said moment compared to moments 1 and 2.

The last stage of the methodology, test and evaluate, has a higher behaviour because the students have already gone through the previous stages, developing skills that allow them to perform with greater security and assertiveness in the last moment of evaluation, which is consistent with the moment when they evaluate the solution that will be presented to the employer and where they apply all the knowledge acquired in the subject. As a result, design thinking can help develop student skills such as critical and creative thinking; problem-solving; teamwork to find innovative solutions, communication; and decision-making based on research results.

The perspective view of the three (3) moments of evaluation manages to identify that the average grades of the students who participated in this analysis are between four (4) and five (5), a positive result for the strategy. Likewise, there is an increase in the performance of learning outcomes sequentially.

Finally, Figure 8 shows the positive evolution that the students who have participated in the Retos programme have had concerning their learning results.

The results in the generic tests, where the percentage of approval of these tests (understood as the percentage of students who obtained a grade above 3.0 on a scale of 1 to 5 in tests to measure generic competencies) shown before starting the challenges
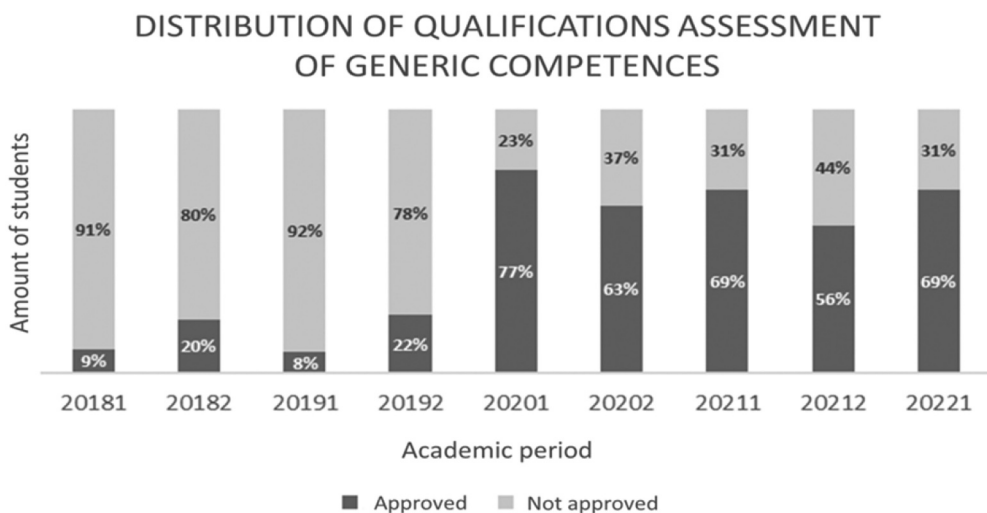
Figure 8. Institutional generic competencies assessment results distribution.

programme in 2020, evidence a substantial increase (55%) in the level of approval in these tests. Although other factors could influence these results, one of the predominant changes these students had was taking the deepening electives of the Challenges Unicosta Program.

These results show the success of the Challenges Program, which has been developed in the Institution on a large scale in all academic programs; since the approval level of the students in these generic competency tests went from 9% in the first semester of 2018 before starting this programme, to 69% in the first semester of 2022.

In this way, challenge-based learning is a pedagogical strategy that focuses on providing students with meaningful and challenging experiences to help them develop skills, knowledge, and values relevant to their lives and future. Students can create a wide range of generic competencies by working on projects and solving real and meaningful problems.

Conclusion and discussions

If the pedagogical approach of learning based on challenges is articulated with the design thinking methodology and the active and continuous assessment instruments, the learning results improved significantly compared to traditional teaching methodologies.

In this sense, what Hamidi et al. (2011) expressed is corroborated when they stated that the variety of methodological alternatives that develop competencies are increasingly noticeable in student performance.

The most used didactic and pedagogical strategies were the workshops, the supports, the exhibitions, the case studies, the round table, the scheme and the conceptual maps, the video forums and the focus groups that is, 80% of the tutors of the Retos programme used 20% of the strategies provided for the development of the stages of the Design thinking methodology, this suggests that there is a concentration or preference towards a set of teaching strategies that proved to be effective within this programme, taking into account that the programme covered all the academic programmes of the University 20 in total.

On the other hand, the subjects where the best averages in the assessment of learning results and DTi projects were presented using the workshops, scheme and conceptual map. In the same way, Storyboards, video forums and round tables are relevant strategies that improve learning and can be articulated with the external sector since, amid their 'rare' use, they respond to external needs (Veflen & Gonera, 2022).

The averages in the performance of the students in the evaluation of the learning results from the deepening subjects worked with the ABR pedagogical approach, demonstrated a positive evolution, evidencing an ascending line that although it decreases in 2021–2 due to the pandemic by COVID-19 stabilises (Figure 4), which shows that the development of the DT methodology in its direct stages had a favourable impact on the results obtained in these subjects and therefore on the development of competencies, as has been proposed Malmqvist et al. (2015).

In addition to using active didactic strategies, evidenced that the teacher has an excellent relationship with the students and assertive communication, motivating the student through words and gestures. To this extent, challenge-based learning is a pedagogical approach that can be very effective not only for developing

generic competencies but also for motivation and commitment to learning (Hamidi et al., 2011). This indicates that the assertive communication between the tutor – student – employers generate a link between motivation and learning as well as enhance collaborative work and products derived from each pedagogical strategy.

The articulation of Challenge-Based Learning and Design thinking improved generic skills up to 55%, the average performance of the evaluation of learning results, and teacher evaluation. Regarding the articulation of the cuts academics into which the semester is divided, which are three, with the stages in which Design thinking is developed, watch Figure 4; it is concluded that the learning process is growing and progressive, which indicates that learning is sequential and with a tendency to improve. This confirms what was stated by Gutiérrez-Mora in 2019 regarding the evidence of the relationship between the monitoring of learning outcomes and the stages of this methodology within the framework of CBL.

The findings show that the institutional strategy contributed to the improvement of the academic performance of the students, promoting the development of innovation and research products that favourably impacted the social environment and the business sector connected with the University, considering feedback as a fundamental axis.

It is essential, then, to consider that the stages of DT promote the design of prototypes that, articulated with the contents of the subjects, generate the application of knowledge in context and, therefore, the development of competencies, as stated by Latorre et al. (2019). In his work design thinking creativity and critical thinking at the university.

Added to the above, this programme generated an institutional impact in that it has strengthened the development of generic skills in students about to graduate as professionals, ensuring their learning and strengthening the training and education of teachers, which strengthens classroom management.

In addition, an external impact has been generated in the medium term, since it strengthened the articulation of the University with the business sector, which positions its training in the labour field with DTI products, social appropriation of knowledge, consultancies, labour contracts, development of some projects that decreased in the greenhouse effect, for example, patents and industrial designs. Long-term impacts are expected for these products to enter the market and be marketed for the benefit of the community.

Disclosure statement

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Notes on contributors

Samara Romero Caballero This author contributes in the methodology and the creation of the flowchart, the conceptualisation around the pedagogical approach learning in challenges and generic competencies. The investigation of data for the construction of information. Formal analysis

of the information obtained, writing the article, reviewing and editing to achieve a quality document.

Liliana Canquiz Rincón This author contributes in the conceptualisation around the pedagogical approach learning in challenges and generic competencies, methodology and description and interpretation of each of the stages. The investigation of data for the construction of information. Formal analysis of the information obtained, writing of the article, reviewing and editing

Andrés Rodríguez Toscano This author contributes to the research, data collection and processing, formal statistical analysis of the data, modeling for the creation through abstractions of the object study with the essential features, writing the article, elaboration of figures and tables with their respective interpretations and contextualisations within the research from a visualisation in the field of the teaching-learning process.

Alejandro Valencia Pérez This author contributes to the document visualisation process from the physical perception of the article and the language, to the mental image that is produced as a product of this perception. The formal analysis of the data, associating them with the methodological stages. Writing, reviewer and editor of this manuscript in English language.

Gloria Moreno Gómez This author contributes to the research with the collection and processing of data, formal statistical analysis of the data, modeling for the creation through abstractions of the object of study with the essential features, the writing of the article, the elaboration of figures and tables with their respective interpretations and contextualisations within the research from a visualisation in the field of the teaching-learning process.

ORCID

Samara Romero Caballero 🆔 http://orcid.org/0000-0002-5885-0337
Liliana Canquiz Rincón 🆔 http://orcid.org/0000-0002-3065-9434
Andrés Rodríguez Toscano 🆔 http://orcid.org/0000-0001-7470-3284
Alejandro Valencia Pérez 🆔 http://orcid.org/0000-0003-1534-583X

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