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The Teaching of Collaborative Creativity, a Methodological Approach to Designing the Environment

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Abstract
The emerging problems are characterized by their high level of complexity. Faced with this scenario, the teacher must propose methodologies that promote collaborative creativity in search of solutions to emerging problems. Designing environments that promote it represents an alternative for this purpose. We conducted this research in a university course that taught collaborative creativity to solve emerging professional problems. It used a methodological approach based on the analysis and adjustments to the educational environment. For this, an Educational Design Research was carried out to improve the environment by identifying and solving its contradictions. We obtained creativity indicators to evaluate the effects of the transformations made to the environment. The overall results showed an increase in the creative value of the products, which we interpreted from the Flow Theory.

Keywords Collaborative creativity · Creativity pro-C · Environment · Educational design research · Flow theory

Introduction

Humanity's progress has brought with it the advent of complex problems that require increasingly creative solutions (Organization for Economic Co-operation and Development, 2021). That is why governments of different countries, scientific agencies, organizations, and companies have invested many resources in programs that seek to develop creativity and innovation (Paulus et al., 2012).

This fact reveals the importance of creativity. Glăveanu (2010) shows the double relevance of creativity, both in its individual and social dimensions. On the one hand, creativity is an attribute of exceptional people (Big-C). On the other, it is also conceived as an inherent ability in all people (Little-C) (Kaufman & Beghetto, 2009) that manifests itself in conversations, practices, and customs that shape daily life (Amabile, 2017; Benedek et al., 2020).

It is essential for social and individual development to promote the creative potential in people, which is why education is vital for this purpose. Education was far from promoting students' creativity because it prioritized using teacher-centered strategies that conceived the student passively. However, Dalke et al. (2007) show that there has been a greater interest in developing and implementing educational strategies encouraging teachers to promote creativity in their students.

Beghetto (2017) mentions that researchers interested in promoting students' creativity have shown that it is possible to achieve it through courses that focus on learning curricular content. He also affirms that another set of interventions promotes general creativity. However, these programs are criticized as just a conglomeration of techniques and advice.

Sawyer (2017) conducted a meta-analysis to identify educational interventions that promote creativity. He defined common characteristics, such as the predominance of a flexible, open, and improvised pedagogy. The prevalence of a relationship between teacher and student based on negotiation. In addition, these interventions implement activities to encourage student decision-making.

The various educational approaches to promoting creativity arise from different theories that allow an understanding of the nature of creativity and its associated factors. Smith and Smith (2010) analyze the existing theories on creativity and their applicability in the educational context. The authors include these theories into three sets, the models

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oriented to the Person, the Process-oriented models, and the Product-oriented models.

Smith and Smith (2010) do not recognize a set of theories focused on the environment which can be incorporated into educational technology to encourage it, even though many investigations allow the understanding of the influence of the environment on creativity. This absence may be because the environment's theories tend to be contextually broader (Kozbelt et al., 2010).

The breadth of these theories may make it difficult to direct this knowledge toward educational purposes. Although in recent years, some research has begun to consider the environmental role in creativity. Hence, it is essential to continue research to understand how the educational environment can favor or hinder creativity from approaches characterized by ecological validity.

On this basis, this study seeks to contribute to the knowledge of how educational design can create an environment that promotes collaborative creativity based on a theory that allows the analysis of the conditions that influence this phenomenon.

In this framework, the research question considers whether we can promote collaborative creativity by improving the educational environment. This study is based on the hypothesis that developing a higher level of collaborative creativity in students through the design of educational environments is possible.

In order to assess the effects of the transformation of the educational environment on collaborative creativity, we evaluated the creative products that students developed collaboratively.

Theoretical Framework

Relevant Considerations on Creativity

GUILFORD (1950) pointed out that creativity remained a little-studied field within psychology for a long time. The point made by the author functioned as a catalyst for research to be increased in subsequent years. Desk research conducted by Kaufman and Beghetto (2009) in Psycinfo revealed that, between 1999 and 2009, around 10,000 articles on creativity were written, demonstrating that it is a widely studied phenomenon. However, it is still a difficult concept to pin down, which has led to a series of definitions and theorizations (Kupers et al., 2019).

Rhodes (1961) counted around 40 definitions of creativity in many published works. Despite the multiple conceptions that creativity can take, Richardson and Mishra (2018) assure that two standard components are originality and usefulness. Originality refers to the degree of novelty, while usefulness refers to the need for something to be effective or valuable.

On the other hand, Rhodes proposed a model that sought to give coherence to the different definitions. This model, known as the four Ps of creativity, places creativity on four levels: the Person, the Product, the Process, and the Press.

Within the study of the Person, research focuses on identifying individual traits related to the creative activity, such as personality or intellect (Rhodes, 1961). Regarding the study of creative Products, researchers have tried to obtain indicators for the elaborations derived from creative activity, such as plastic works, technological artifacts, and writings (Amabile, 1982).

The research on the Creative Process describes the phases and mechanisms of creating novel products (Kilgour, 2007). In contrast, the scrutiny of the Press seeks to establish the relationship between the individual and the environment. From this approach, the authors presume that the great inventions in the history of humanity have rarely been the result of an individual but are the product of small contributions that accumulate historically (Csikszentmihalyi, 2015).

In recent years, some proposals have sought to integrate the different levels in the study of creativity. From cultural psychology, an approach has emerged that recognizes creativity as not exclusively anchored in the creative Person but distributed through interactions with others, artifacts, and history.

Sustained by the principles of distributed cognition (Cole & Engeström, 1993), this sociocultural approach establishes that every creative act is distributed, even when the act occurs in a solitary way. It happens because people create new products from the ideas of others, using tools made by others, and above all, addressing cultural elements that belong to everyone (Literat & Glăveanu, 2018).

These approaches define creativity as those situations in which a group of people collaborates to generate a shared product (Sawyer & DeZutter, 2009) and is characterized by novelty and usefulness.

Alternatives for the Evaluation of Creativity

Within the study of creativity, there has been significant interest in obtaining various indicators of the attributes that characterize it. According to Kupers et al. (2018), it is possible to distinguish three predominant levels in evaluating creativity, corresponding to three dimensions that make up Rhodes's four Ps of creativity (1961). These three levels are the Person, the Process, and the creative Product.

At the Person level, the assessment relies on psychometrics to develop tests that measure creative personality (Guilford, 1950) or creative thinking. Within this last sphere of evaluation, one of the most widely recognized works is the Torrance Test of Creative Thinking (Torrance, 1966).

Within the evaluation of the creative process, Kupers et al. (2018) proposed a methodology that allows evaluating creative micro-development in real-time, which is an alternative that promises an approach to the interactions established between people, products, and creative tasks.

Finally, one widely used technique in evaluating creative products is the Consensual Assessment Technique (CAT) (Amabile, 1982). This widely used technique is an evaluation tool based on a consensual operational definition of creativity. The CAT intends that a group of evaluators generate an independent agreement on the creative value of a product.

The CAT starts from the assumption that creativity is a quality that is socially, historically, and culturally guided, so it is impossible to determine an objective scale for its evaluation. Hence, evaluations are always subjective, so this technique generates an intersubjective appreciation of creativity (Amabile & Pillemer, 2012).

The Design of Environments to Promote Creativity

The different investigations carried out in the field of creativity have been the frame of reference for its promotion from education. For many years, traditional instructional-centered educational models prioritized rote learning over developing creative potential. However, a meta-analysis carried out by Sawyer (2017) revealed an increasing interest in constructivist methodologies focused on designing environments that help students participate in creative processes.

This interest in the environment for the promotion of learning and creativity has made possible the transformation of the teaching role, which abandons the function as an exhibitor of curricular content, to become a designer of the sociocultural conditions that allow compliance of educational objectives.

Hence, educational environment design is a process that allows structuring the components that make up the learning context. Akkerman et al. (2013) point out that educational environment design relies on theories, methodologies, and observations to favor creating and implementing new tools to consummate teaching.

Recently, a conception of educational design has been consolidated, starting from empirical research to planning and structuring learning experiences. This framework is known as Educational Design Research (EDR) (Van den Akker et al., 2006). EDR is an approach that combines empirical investigation of natural environments with the systematic development and implementation of solutions to educational problems.

EDR is a theoretically oriented approach. That is based on existing theories that help to frame the research and interpret the data collected. It is an interventionist approach that seeks to positively impact practice by transforming the environment and solving educational problems. Also, it is a collaborative approach since EDR requires the collaboration of the actors related to the problem in question. It is also a grounded approach from the perspective of the participants. Finally, it is an iterative approach, implying that knowledge and interventions are reworked over time (McKenney & Reeves, 2018).

The importance of this approach within the study of creativity lies in the fact that EDR is a tool that allows obtaining empirical and situated references on how the environment influences the promotion of this attribute.

Collaborative Learning: an Alternative for Educational Design

Collaborative learning is an approach that can guide the conception of an educational design, which involves collective work to solve a problem, perform a task, or create a product. Collaborative learning is based on sociocultural premises that conceive learning as a social act, based on speech or conversation, as the principal means for constructing knowledge (Laal & Laal, 2012).

Slavin (1980) was one of the first educators to implement collaborative educational designs. This researcher considered three fundamental elements that guide the characteristics of educational design with this orientation: the structuring of tasks, rewards, and authority. Slavin points out that it is possible to obtain arrangements that promote various aspects of collaborative learning based on these factors.

A Theoretical Approach to EDR

One of the characteristics of EDR is the importance of guiding the analysis and transformations, starting from a theoretical approach.

Cultural-Historical Activity Theory (CHAT) is an approach that allows directing research. It is an explanatory framework based on the principles postulated by Vygotsky, Luria, and Leontiev on the conceptual delimitation of consciousness. Starting from the notion of the activity system incorporated by Leontiev (1974), CHAT seeks to explain the development of complex configurations of human action.

In this context, an activity system considers the relationship between the individual and the environment, mediated by different artifacts that allow operating on it. The components of an activity system are the individual, the object, the tools, the rules that regulate the actions, the community to which the individual belongs, and the division of tasks that organizes work (Cole & Engeström, 1993).

Being conceived as the basic unit of analysis, the notion of an activity system is crucial because it allows the establishment of components through which the educational environment of a course is distributed. The CHAT provides a series of conceptual and methodological resources to carry

out Educational Design Research, which simultaneously allows the transformation of the environment to promote better conditions for the creative activity of students.

Contradiction as a Concept for the Analysis of the Environment

One of the central concepts of CHAT is the notion of contradictions, understood as imbalances, tensions, and conflicts that accumulate systematically and historically, generating distortions in the activity script (Engeström, 1987).

For Murphy and Rodríguez-Manzanares (2008), contradictions are disruptive events. However, Karanasios et al. (2017), far from conceiving contradictions as unfavorable issues, emphasize that these are elements of wealth, mobility, capacity for development, growth, and system expansion.

Within the EDR, contradiction can be of great relevance in identifying and analyzing anomalies in an educational environment for its eventual transformation in search of better conditions for creativity.

Based on the theoretical approach expressed, the development of creative products in the students' work was promoted based on the analysis of contradictions and adjustments to the educational environment design.

Method

Context

We studied a university group of 20 students who were part of an educational psychology course, which sought to encourage students to develop creative proposals for educational intervention (Pro-C). The course in question ran for two semesters.

Based on the principles derived from collaborative learning (Slavin, 1980), we organized the students into five teams of four members each. During the course, students reviewed various topics related to educational psychology. Each team selected a specific theme and analyzed an educational problem linked to the selected theme. The students had to conduct a bibliographic search of the subject; then, they had to observe a situated case of the defined problem and propose a creative solution.

To encourage creativity in proposals, we based the course design on the guidelines outlined in Sawyer's (2017) meta-analysis. For this reason, we designed the course with a profoundly socio-constructivist emphasis since collaboration fosters the emergence of conditions in which two or more people recognize their complementarity of experience and resources necessary for creating new artifacts (Miettinen, 2013).

We oriented the creative activity to students' interests; the teacher served as a guide in promoting students' autonomy in decision-making. We also created an environment to recognize and stimulate the generation of creative ideas.

Design

We conducted an Educational Design Research (Van den Akker et al., 2006). In this context, the research had a dual purpose: (1) to generate systematic knowledge about the environment; (2) to produce a prototype that benefits collaborative creativity.

As shown in Fig. 1, we developed this research through 4 phases, which we describe below.

Phase I: Execution of the Original Educational Design

During the first semester of the course, we implemented an educational design structured in different stages to facilitate the development of intervention proposals made by the students. In the first stage of Phase I, we presented the objective of the course to the students, to whom we indicated that they would develop a project throughout the semester to address an educational problem in a school, which would conclude with a creative proposal for educational intervention (Pro-C).

Subsequently, five teams were formed based on the different abilities of the students to generate diversity. Once integrated, the students chose an educational topic of interest to direct the collaborative activity.

The next stage consisted of collaborative creativity that lasted almost four months. We provided the teams with protocols containing suggestions to guide the project development for collaboration. This project included the selection of a problem and its bibliographic review, the specific approach of the problem to be treated, the empirical observation of the problem, and, finally, the elaboration of an intervention proposal that had to be creative, that is, innovative and useful.

The protocols started by requesting each team member to develop an individual suggestion for collaborative creativity so that each student could contribute their creative ideas to the collective work.

Subsequently, the protocols asked the students to present their elaborations to their classmates. In each team, members generated a deliberation of the ideas and created a product shared by consensus.

After twelve stages, each team concluded the activity with a creative intervention proposal for the delimited problem.

Phase II: Implementation of a Change Laboratory

At the end of the first semester, we analyzed the educational design. A methodological proposal derived from the CHAT was used, known as the Change Laboratory. Its main

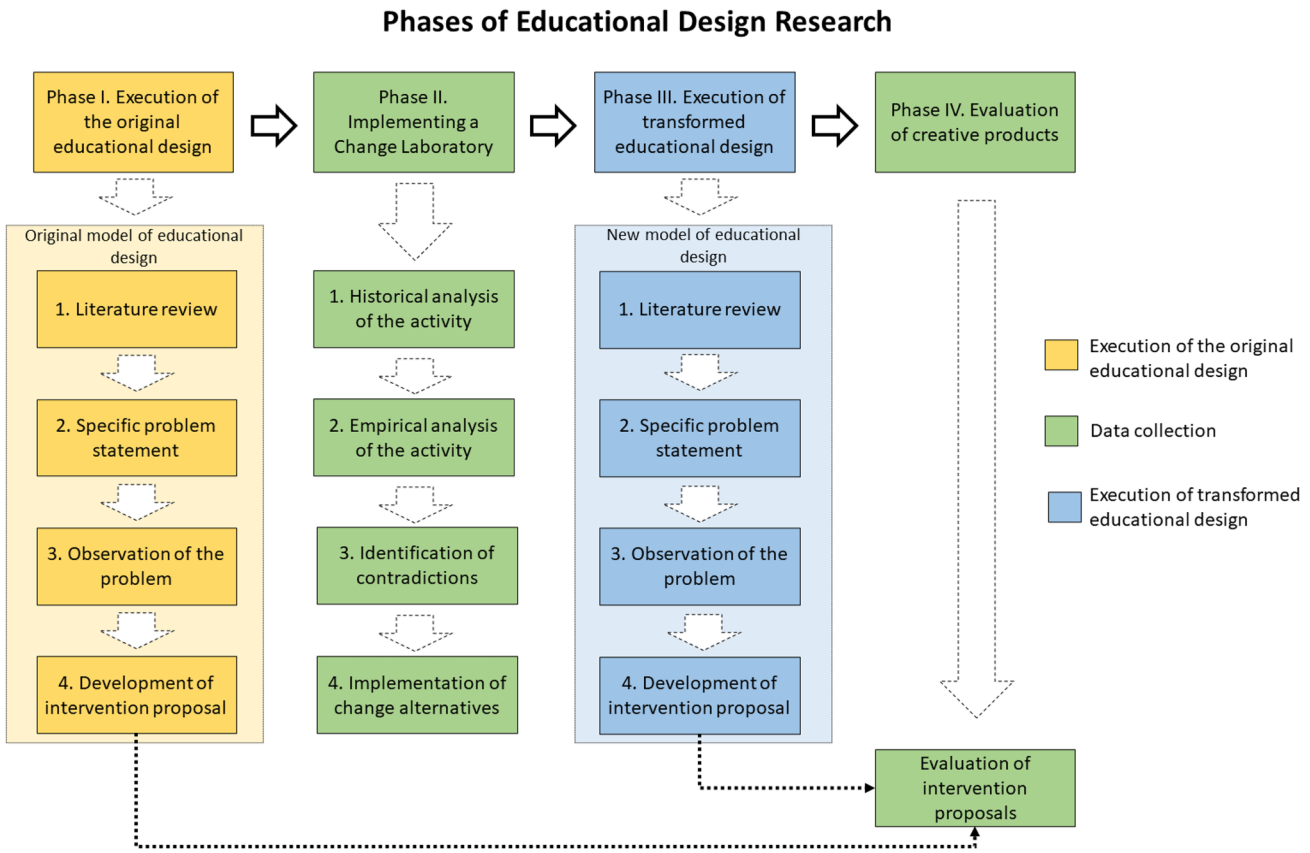

Fig. 1 Phases of educational design research

characteristic is that it provides different instruments for analyzing contradictions and creating new artifacts that mediate activity (Engeström et al., 1996).

The implementation of a Change Laboratory implied the participation of the teacher and the students of the course. Its purpose was to identify and analyze those contradictions in the educational environment which caused deviations and tensions in collaborative creativity. We assumed that a favorable environment for creative processes would allow teams to focus on the task. For this reason, the educational environment would provide better conditions for the teams to integrate more creative educational proposals by resolving or attenuating the contradictions.

Throughout Change Laboratory sessions, the teacher, the students, and the researcher participated in collecting and analyzing data. We configured the Laboratory in four sessions. First, students and researchers interviewed the teacher to learn about the historical development of the course. Both the researcher and the students took notes on the crucial events reported. Subsequently, all analyzed the information collected, organizing it historically and identifying the change events. At the end of the first session, the teacher presented the developed analysis to validate it.

During the second session, all participants analyzed the students' performance in the creative task. Within this analysis, different data sources were consulted, such as the course regulations (Syllabus), the expected scripts of the creative task, and those working documents the teams developed. To identify the problems raised in the creative task, each team reflected on their difficulties in carrying out the planned activities.

In the third session of the Change Laboratory, we delimited the contradictions inherent in the educational environment. All the participants identified the recurring problems (patterns) that the teams experienced in the creative task and the possible systemic causes that explained these problems.

Next, the teacher and the students proposed alternatives for change that would allow the contradictions to be resolved or mitigated. In each team, the students proposed possible solutions. The team's task was to critically analyze the proposed solutions and select which one was considered the most effective and viable. Finally, each team presented its change alternative to all the course participants, who analyzed the proposals to select the most effective and viable ones.

Phase III: Execution of the Transformed Educational Design

At the beginning of the second semester, we implemented a new educational design because of the identification and analysis of the contradictions. Each team developed a new intervention proposal to weigh the effects of the transformations made to the educational environment.

Phase IV: Evaluation of Creative Products

We obtained creativity indicators from all the intervention proposals made by the students to evaluate the transformations in the educational environment. Creativity indicators sought to compare the proposals made by the teams during the first semester with those developed during the second.

We used the Consensual Assessment Technique (CAT) described by Amabile (1982) to evaluate the creativity of the intervention proposals prepared by the teams. Since Amabile suggests that it is essential that the evaluators are experts in the field in question, it was considered an inclusion criterion that the evaluators had at least one year of work experience as teachers. In this regard, we invited fifty-one educational psychologists to participate as evaluators of the students' proposals.

Of the fifty-one, just thirty educational psychologists fulfilled the inclusion criterion. Also, we applied a validity and reliability test, and we only considered fifteen educational psychologists who had obtained the best scores.

The assessment process of the ten intervention creative proposals was carried out separately by each evaluator to guarantee the independence of the evaluations. We provided them with a digital booklet containing the ten proposals and the instructions.

In the evaluation, the judges were first asked to order the proposals from most to least creative and then to repeat the process but now considering the proposals' pertinence. The instruction was to assess two dimensions independently. On the one hand, creativity was understood as originality comparing the ten proposals; on the other hand, pertinence was defined as the degree to which each judge appreciated the appropriateness of the proposal to solve the problem. We presented the proposals and the dimensions randomly to avoid any effect on the order.

The evaluators operated on a spreadsheet that served as the evaluation instrument. We used a coin-based value scheme to make the task easier, in which each one was worth more than another. Evaluators had to award the coins leaving the highest-value coin for the best proposals and the lowest value for the worst.

Results

The data collected from the Change Laboratory was analyzed to understand the course's educational environment. In contrast, we analyzed the data collected from the CAT to obtain indicators of the products of collaborative creativity.

Analysis of Educational Design

The educational design analysis was based on a proposal derived from the CHAT known as Activity System Analysis (ASA), which identifies and examines the inherent contradictions in a system (Engeström, 1993).

The ASA was used to identify contradictions in the course in question. We configured this analysis on two levels: the first highlights the transformations in the historical development of educational design, and the second corresponds to the empirical level of collaborative creativity.

Historical Analysis of the Activity

This level aimed to generate a historical context of the current situation of the course. For this matter, we collected the data in an interview with the teacher. The students participated by asking the teacher questions and taking notes on his report.

The participants developed a timeline that allowed the organization and schematization of the information collected (Fig. 2). The timeline highlighted the historical contradictions in educational design and the main changes to resolve them.

This analysis showed that a large part of the educational design transformations resulted from various contradictions that the teacher experienced in the history of the course. Similarly, this analysis allowed students to understand the theoretical and practical reasons underlying the design of their activities.

Empirical Analysis of the Collaborative Creativity

The empirical analysis allowed the understanding of the current educational environment and recognition of the contradictions that the students experienced in developing the proposals.

We derived this analysis from text data sources, such as the Course Regulations, where the general guidelines are expressed. We also consulted the Activity Protocols, which are scripts with some recommendations for collaboration. In addition, we used different records of the student's activities, such as chat conversations and text documents, in which each team developed its proposals.

Based on this, the educational design of the course, conceived as an activity system, was analyzed, which made it possible to delimit how it was structured (Fig. 3).

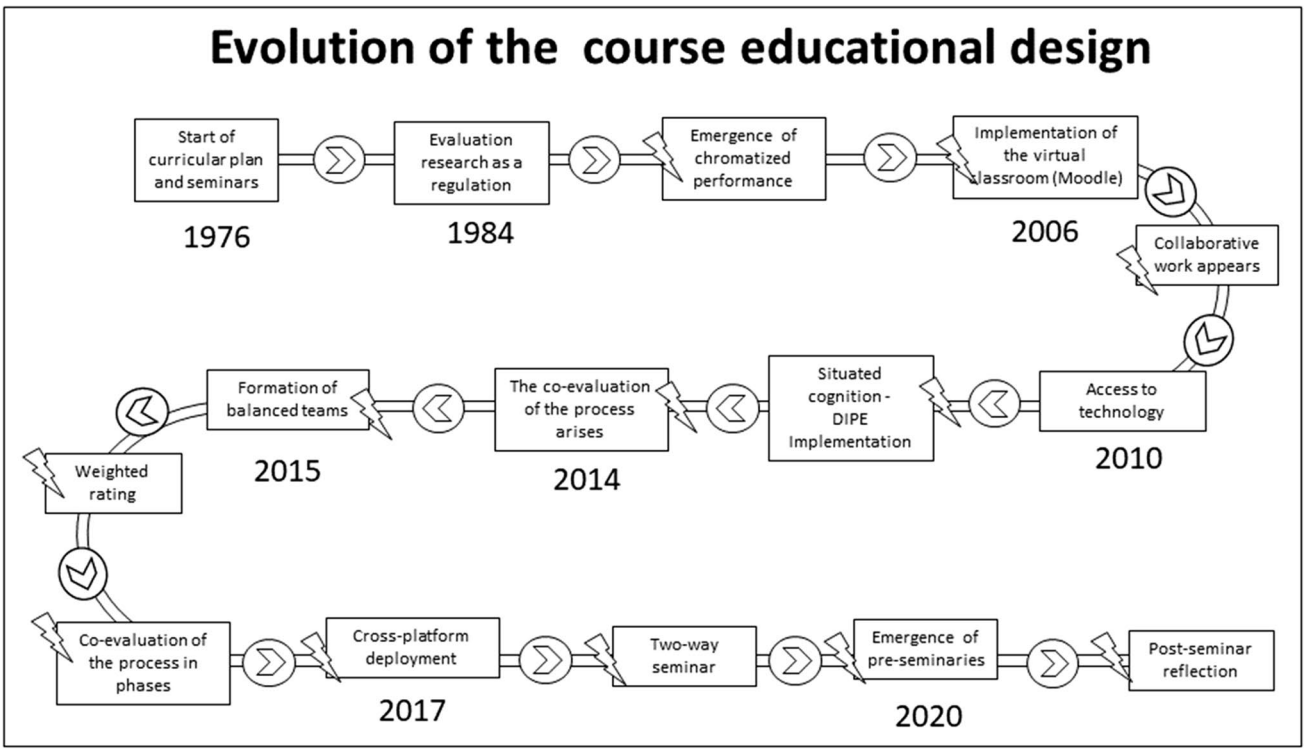

Fig. 2 Historical development of the course design

In analyzing the collaboration records, we compared the scripts prescribed in the Protocols and the actual activity in each team. Based on flow charts, the teams made representations of the expected script and the actual direction of the activity.

Figure 4 is an example of the most recurrent deviations in teams. The diagram above illustrates the expected activity script, while in the lower diagram, the disorganized way the individual actions took place, identified with dashed red lines, is observed. These deviations generated changes in subsequent tasks and delays in activities. Simultaneously, the delays caused the teams to omit tasks to comply with the times for each stage.

From recognizing the most recurrent deviations, the researcher, the teacher, and the students sought to identify the systemic causes of the deviations, that is, the contradictions inherent in the educational design of the course. The analysis yielded two contradictions: the first related to the organization of the teams and the second regarding the workload.

Implementation of Prototypes for a New Collaborative Creativity Model

In the last session of the Change Laboratory, we promoted the generation of alternative solutions through collaboration to mitigate the previously mentioned contradictions. This process culminated in incorporating two prototypes into the educational environment.

The first was implementing an instrument facilitating activities division and monitoring pending tasks. This artifact sought to improve the organization of teams.

The second one was the implementation of synchronous work sessions. This proposal attempted to generate spaces within the course to carry out collaborative activities during class hours.

The incorporation of the synchronous sessions meant merging and synthesizing the course activities. The above simultaneously implied the improvement in the organization of the teams and the reduction of the workload. Both alternatives were incorporated into the educational environment to test them during the second semester.

Indicators of Creativity in Products

We transformed the educational environment to improve the conditions for creative activity. The data derived from the CAT was analyzed to obtain indicators.

Evaluation of the Judges

The best 15 evaluators were selected to increase the quality of the indicators. This selection was based on the coincidence between the evaluations (reliability) and each judge's discrimination capacity (validity). We considered these two criteria since they are directly related to the essential need

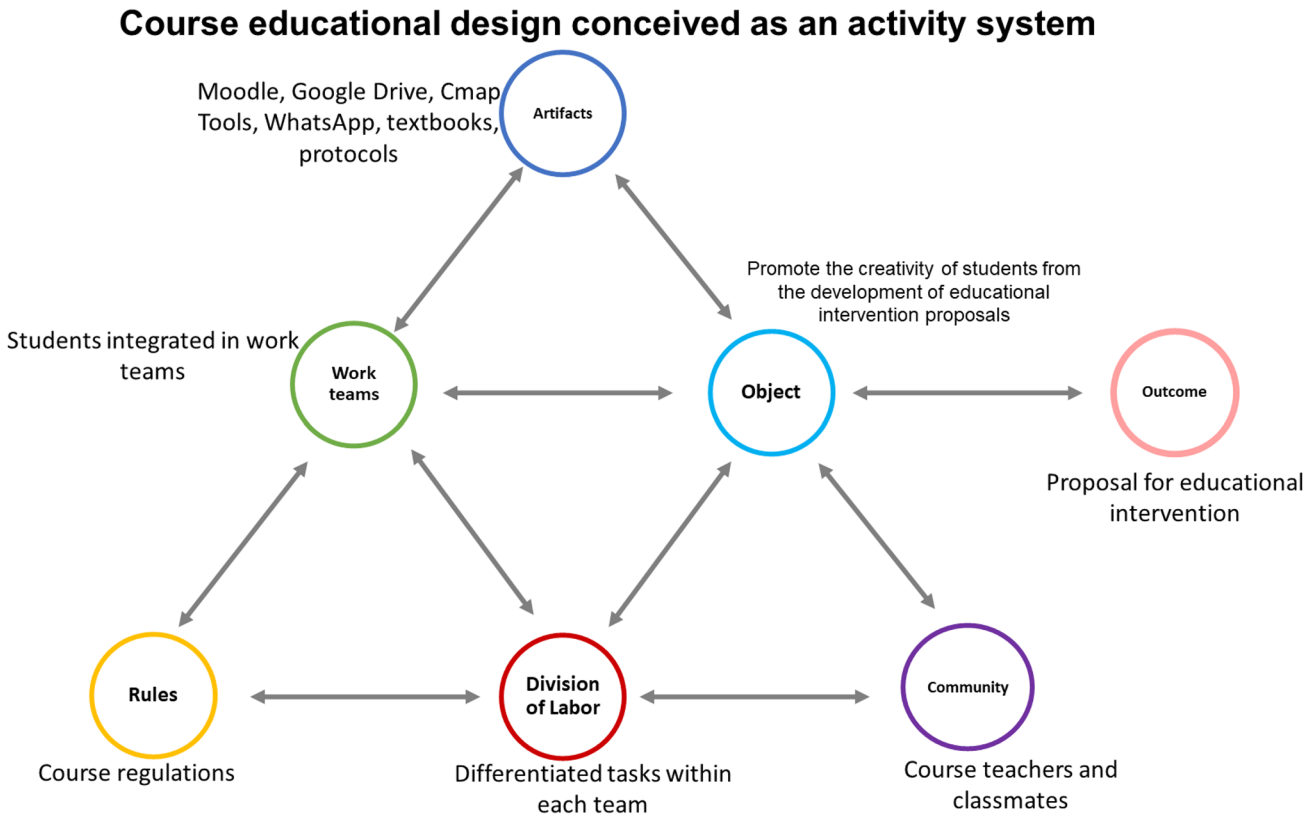

Fig. 3 The educational design of the course as an activity system

to have indicators that guarantee the quality of the evaluation procedure.

Regarding the coincidence, we estimated the sum of the squares of each judge concerning the mean obtained from each proposal. The judges were ordered based on this indicator, considering that the lower the score, the greater the agreement concerning the majority's opinion, which translates into greater reliability.

With the second criterion, we attempted to identify the judges who best differentiated creativity from pertinence. We calculated the correlation of the set of scores given by each evaluator in both dimensions; with this, it was possible to appreciate the independence of the assessments made to the intervention proposals, considering their creativity and pertinence separately. The judges were ordered, considering that the bests were those who showed the lowest correlations since this implies a better ability to recognize the difference.

Table 1 is the result of both statistical procedures. The first column shows the 30 judges who participated in evaluating the proposals.

The following section contains the indicators to evaluate the closeness of their evaluations concerning the judges' average. With these values, we ordered the judges to assign the first position (1°) to the judge with the least distance from the mean. We continued the ordering to assign the last position (30°) to the most distant.

The third section shows the estimated indicators to evaluate the discrimination capacity of each judge. The first column of this section contains the correlations of the scores made by the evaluators between the two dimensions. The next column contains the relative position of each judge, in which the first position was the judge who showed the lowest correlation and the last position with the highest correlation.

Finally, we calculated an average position by estimating the positions in both criteria. The judges with the best positions in this last indicator were selected since this meant the best performances in the two criteria. We selected fifteen judges to decrease the two statistical errors.

Normality Test

We evaluated the normality parameters of the selected sample. We used the Kolmogorov–Smirnov test for statistical analysis, showing that this sample does not follow a normal distribution ($p < 0.05$). Therefore, we used non-parametric tests to obtain the different indicators.

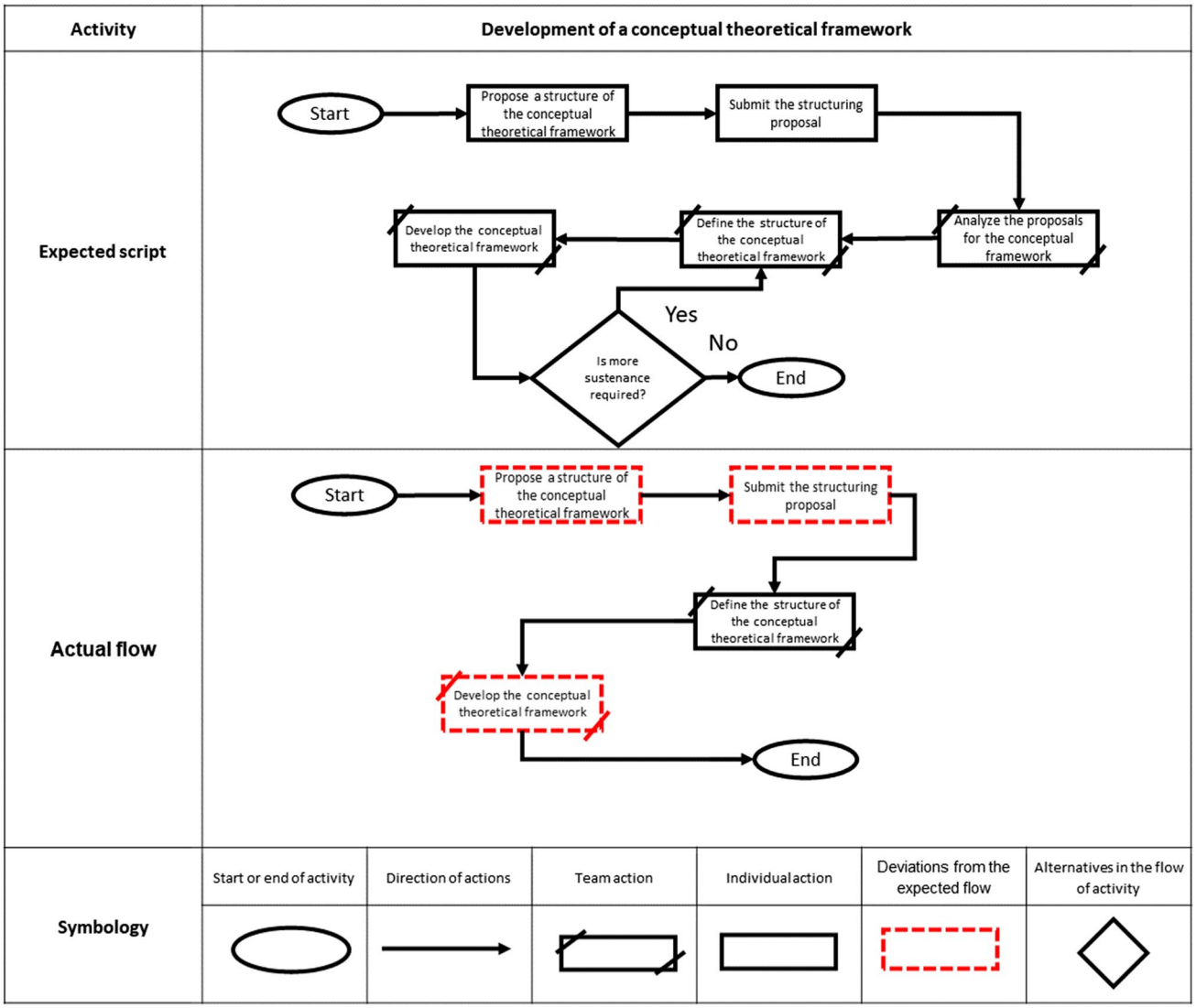

Fig. 4 The contrast between the expected script and the actual activity

Reliability and Validity

The reliability calculation was performed based on Kendall's coefficient of concordance; the multivariate non-parametric version used to determine the level of agreement between judges (Field, 2013).

Table 2 summarizes the agreement calculation, which indicates a statistically significant agreement ($W = 0.487$, $p < 0.001$).

Amabile (1982) considers that the reliability of ratings is the best validity criterion for creativity since if the appropriate judges independently agree that a product is highly creative, it should be accepted as such. In addition, we also used discriminant validity because, as she mentions, it is also essential to show that judges can separate creativity from other dimensions. This research differentiated creativity from pertinence, correlating each dimension's judges' scores based on Kendall's Tau (Field, 2013).

Table 3 shows a relatively low and statistically significant correlation ($\tau = 0.304$, $p < 0.001$), which shows that the judges could differentiate the creative value from the proposals' pertinence.

Group Indicators of Creative Products

To appreciate the development of creativity, because of the adaptations to the educational design generated in the Change Laboratory, the creative products developed during the two school semesters were compared.

We constructed group indicators for both semesters to make the comparisons, which refer to those statistics that

Table 1 Selection of the best judges

Judge	Coincidence		Discrimination		Average position
	Sum of squares	Position	Correlation	Position	
Judge 03	45.3	2°	0.18	4°	**3°**
Judge 20	54.5	7°	-0.07	2°	**4.5°**
Judge 08	54.7	8°	0.32	7°	**7.5°**
Judge 22	62.7	13°	0.20	5°	**9°**
Judge 12	50.5	3°	0.50	17°	**10°**
Judge 13	64.6	16°	0.21	6°	**11°**
Judge 10	52.4	5°	0.64	23°	**14°**
Judge 18	70.8	19°	0.35	9°	**14°**
Judge 02	95.3	27°	0.18	3°	**15°**
Judge 06	106.2	29°	-0.19	1°	**15°**
Judge 15	83.6	22°	0.33	8°	**15°**
Judge 17	60.9	12°	0.54	18°	**15°**
Judge 19	63.9	15°	0.48	15°	**15°**
Judge 27	68.5	17°	0.43	13°	**15°**
Judge 29	54.7	9°	0.61	21°	**15°**
Judge 04	57.5	11°	0.60	20°	15.5°
Judge 25	44.4	1°	1.00	30°	15.5°
Judge 28	54.4	6°	0.83	25°	15.5°
Judge 05	50.7	4°	0.95	28°	16°
Judge 09	69.7	18°	0.47	14°	16°
Judge 01	63	14°	0.62	22°	18°
Judge 11	55.3	10°	0.93	26°	18°
Judge 24	71.3	20°	0.49	16°	18°
Judge 21	87.1	25°	0.39	12°	18.5°
Judge 23	100.8	28°	0.35	10°	19°
Judge 07	79.2	21°	0.59	19°	20°
Judge 30	132.6	30°	0.36	11°	20.5°
Judge 26	84.6	24°	0.64	24°	24°
Judge 16	83.8	23°	0.95	29°	26°
Judge 14	88	26°	0.93	27°	26.5°

In the last column, we highlighted in bold the average position of the fifteen selected judges

give a general overview of the changes in the creativity of the proposals. We took the set of proposals developed each semester as the analysis unit.

We based this analysis on the grades given to proposals. We grouped them according to the semester to which they belonged. In this way, we calculated the average score of the evaluations of the first and second semesters.

Table 2 Estimation of the reliability of the evaluation

Test statistics	
N	15
Kendall's *W*[a]	0.487
df	9
Sig	0.000

Kendall's coefficient of concordance

Figure 5 summarizes the averages of the evaluations of the ten proposals grouped by semester. We observe that, for the proposals made during the first semester, the average grade obtained was 4.35, while for the proposals prepared during the second, the average was 6.65. It represents an increase of 2.3 points, equivalent to an improvement in creativity of 53%, concerning the average obtained in the first semester, although it is only a general indicator.

Table 3 Estimation of validity

			Pertinence
Kendall's tau	**Creativity**	Correlation coefficient	.304
		Sig	0.000
		N	150

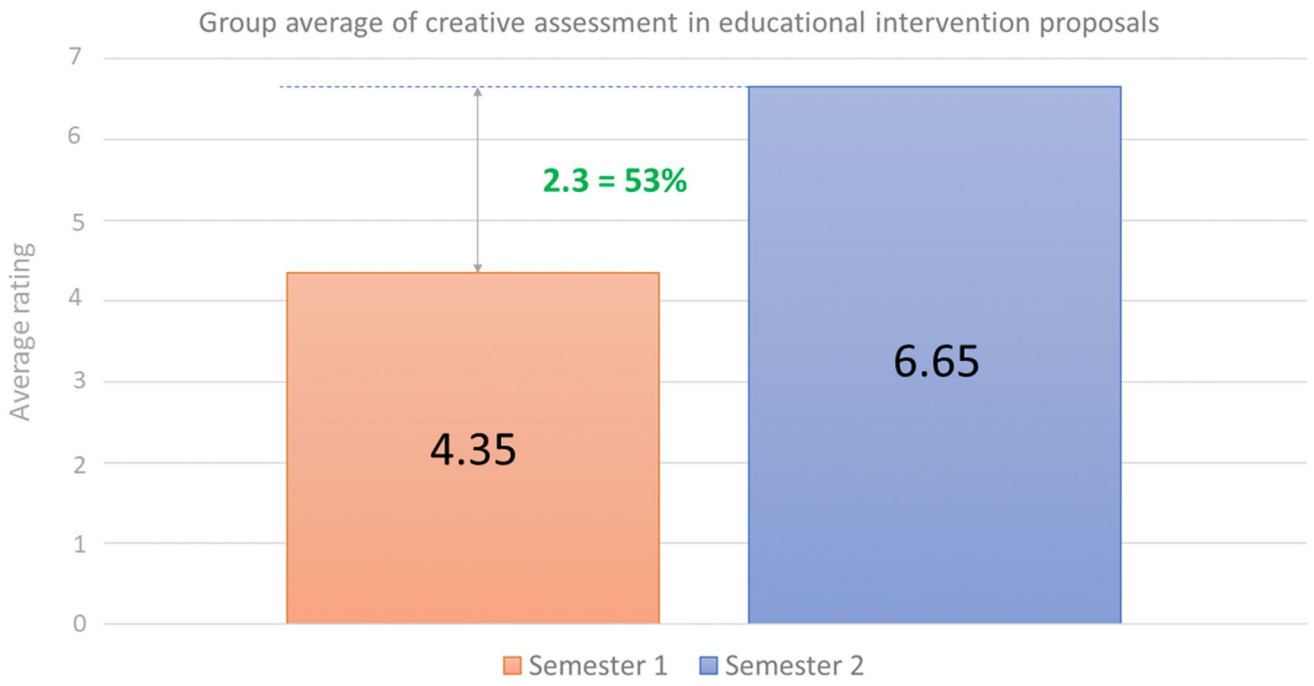

Fig. 5 Group average of creativity in the proposals

Using a Wilcoxon signed-rank test (Field, 2013), the level of statistical significance was determined. Table 4 shows the test results, indicating that said difference is statistically significant ($W = -4.061$, $p < 0.001$).

Indicators by the Team of Creative Products

Although the total estimated gain was very high (53%), we considered how homogeneous this gain was, for which we analyzed the variance between the teams.

We analyzed teams' performance regarding their proposals' creativity through creativity indicators per team. Each of the five teams integrated into the course was considered the unit of analysis. We estimated the performance averages obtained in each team's first- and second-semester proposals.

Table 4 Non-parametric comparison of means for semesters 1 and 2

Test statistics	
	Semester 1 vs semester 2
Z	−4.061
Sig	0.000

Wilcoxon's signed-rank test

In Fig. 6 are the teams' trajectories, which we defined from the average obtained in the two intervention proposals they developed. We observe various behaviors in terms of trends established in the data. Regarding teams 2, 4, and 5, creativity in the proposals of the second semester had increased compared to the first. However, teams 1 and 3 were unexpected; in team 3, there was no gain, and in team 1, there was a significant loss. In team 3, there was a slight decrease of 0.47. Nevertheless, in team 1, a noticeable decrease equivalent to 2.4 points (−47%) is observed.

We applied a Wilcoxon signed-rank test (Table 5) for each team's proposals. With this, we identified which differences represented a statistically significant difference.

The test results confirm what we observed in the descriptive analysis. In teams 2, 4, and 5, the increase represents a statistically significant difference (green font), which shows that creativity in the intervention proposals was favored.

In team 3, as expected, the slight decrease in creativity was not statistically significant (yellow font), so we can say that, although the adjustments to the design did not improve creativity, they did not impoverish it either.

In team 1, the test shows that the decrease in the score was statistically significant (red font), indicating that the proposal made by this team during the second semester was less creative. We analyzed this unexpected data in the discussion.

Table 5 Non-parametric comparison of means by the team

Test statistics[a]					
	Team 1	Team 2	Team 3	Team 4	Team 5
Z	-2.229	-3.332	-.342	-3.422	-3.273
Sig.	0.026	0.001	0.733	0.001	0.001

[a]Wilcoxon's signed-rank test

Team	Semester 1	Semester 2	Difference
Team 1	5.93	3.53	-2.40
Team 2	3.00	7.40	4.40
Team 3	6.33	5.87	-0.47
Team 4	3.00	8.00	5.00
Team 5	3.47	8.47	5.00

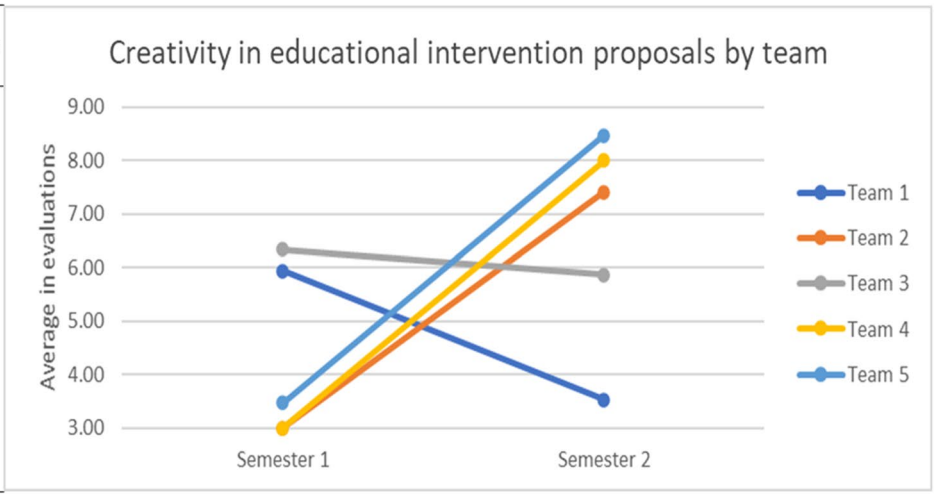

Fig. 6 Average creativity in proposals by the team

Discussion and Conclusions

The Importance of the Environment for the Promotion of Creativity

As Richardson and Mishra (2018) point out, the study of creativity continues to be a phenomenon on the researchers' agenda. However, they warn that researchers still need to pay more attention to the environment's impact on promoting creativity. This research aimed to provide empirical evidence on the relationship between the design of learning environments and the promotion of creativity.

For this purpose, Educational Design Research (EDR) was considered an approach characterized by its interest in studying the design underlying learning environments from a theoretically oriented, interventionist, collaborative, grounded, and iterative perspective (McKenney & Reeves, 2018).

An EDR was carried out based on the Cultural-Historical Activity Theory, which provided theoretical and methodological tools that allowed the educational design analysis of an educational psychology course and its subsequent transformation. The educational design analysis identified that said course had anomalies (contradictions), which hindered its central mission: to encourage students to develop creative intervention proposals.

The two contradictions identified referred to the disorganization of the teams and the work overload inherent in the development of the proposals. To a large extent, the deviations in the collaborative creativity were because the members of each team experienced difficulties in establishing moments that would allow them to distribute the work and generate agreements on the actions to be carried out.

This last point is reasonable when we recognize that students are social agents who participate simultaneously in various activity systems, which can exert irreconcilable demands, generating tensions between and within the systems. For example, a student usually participates during a school semester in more than one academic course, which sometimes puts the student in conflict because each course demands time and resources that are sometimes incompatible.

When educational design promotes teamwork, students are commonly required to create extracurricular times for

collaboration, that is, to meet outside of class. However, given the requirement of simultaneous participation, students sometimes find different times to carry out collaborative activities, eventually leading to conflicts that hinder collaborative creativity.

We linked the second contradiction to the development of the intervention proposals. The analysis of the deviations confirmed that the teams perceived an excessive demand for work. This perception is related to disorganization since the lack of agreements caused some teams only to complete the planned actions on time. Therefore, upon reaching a new stage, the teams perceived an excessive accumulation of work.

The analysis shows that, when seeking to promote collaborative creativity, the teacher starts from a theoretical-methodological vision that guides the conception of the educational environment of their course; however, when operating in the empirical reality, different anomalies emerge that are not contemplated in the design, hence the importance of analyzing and investigating the design in a systematic and iterated way, based on different tools that allow the identification of problems and the implementation of alternative solutions.

This task requires the teaching effort and the participation of all educational actors since the multiple perspectives significantly enrich the collection, analysis of data, and generation of transformation alternatives.

Creativity Indicators

From the Consensual Assessment Technique (Amabile, 1982), we obtained indicators of the changes in the creative value of the proposals. The group indicators show that, in general terms, there were statistically significant changes, indicating that the proposals made after the educational environment's transformation were more creative than those presented by the teams during the first semester.

It is pertinent to return to the approaches of Csikszentmihalyi to link the increase in creativity with the transformations carried out through the Laboratory of Change. His Flow Theory describes a cognitive state in which a person channels all his resources to execute a specific task (Csikszentmihalyi, 1990).

Within the study of creativity, the author uses this concept to point out that flow allows creative people to stay focused on the task and get lost in the creative process. This state promotes confidence for creative activity to emerge without any restriction. Therefore, the creative act must be free from distractions or events that hinder it (Csikszentmihalyi, 1997).

Although Csikszentmihalyi raises the importance of flow for creativity at the Person's level (Rhodes, 1961), it is possible to extrapolate these principles to collaborative creativity. The educational environment analysis evidenced the existence of circumstances that constantly stressed the creative process.

The lack of organization and the work overload perceived by the teams represented two distractors that disturbed the flow of collaborative creativity. Instead of concentrating on strictly academic activity (the creative elaboration of their proposals), the teams focused their interactions on the attempt to contend with the contradictions implied by the course.

When the implementations mitigated the contradictions, the teams could direct the resources to the creative task, which allowed the collaboration to have a higher flow state.

The analysis by each team of the creative products showed that the teams had different performances. Creativity increased in teams 2, 4, and 5; in teams three, it decreased slightly, while in team one, creativity decreased significantly. These last two cases are interesting for discussion since their creative performance trajectory differed from expected.

To explain what we observed, we investigated the work dynamics of the two teams in question from a brief review of their activity records.

In the case of team 3, the exploration allowed finding narratives by chat, where we observed that this team had fewer difficulties organizing itself than the other teams. For team 3, it was relatively easy to reconcile their times to continue collaborative work. They wrote even the best proposal in the first semester. This case shows that the degree to which organizational problems arise is different in all teams. Therefore, the implementations made to the educational design favored some teams more than others.

It is essential to recognize that other uncontrolled incidence factors may interact to explain the loss in team 1 performance. For example, during this course, the pandemic affected in different ways to each student.

Limitations and Future Research

The research was based on indicators focused on the creative products developed by the students. This level of analysis of creativity is characterized by its high reliability and validity; however, the study of creativity focused on the product does not allow studying the process behind these elaborations, which can provide valuable data to understand how the environment impacts collaborative creativity.

In the case of the reported research, given that the creative process was not studied, no elements confirmed whether the elaborations made by the teams were the result of collaboration or were only the result of individual activity.

Likewise, the study of the process within the research could have clarified the atypical results obtained in evaluating the proposals made by teams 1 and 3. Kupers and collaborators (2018) propose a feasible methodological alternative to studying the creative process, which stands out for analyzing the micro-development of creativity.

It is important to continue investigating the educational environment design's role in promoting creativity, looking for theoretical and conceptual bridges that broaden our understanding. Eventually, the findings can be incorporated into educational technology oriented to these purposes.

In this study, the process involved in educational environment design can be a factor that contributes to the development of creativity. Creativity allows students to be better equipped to face emerging problems derived from transformations in the contemporary world in a way that allows them to build a better future for themselves and society.

Author Contribution All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Jesús Peralta and Felipe Tirado. The first draft of the manuscript was written by Jesús Peralta and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability The datasets generated during and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics Approval The authors declare that the study was approved by the ethics committee of the National Autonomous University of Mexico.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Conflict of Interest The authors declare no competing interests.

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