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Idea generation and integration method for inclusion and integration teamwork

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Idea generation is fundamental in higher education, principally in engineering and creative areas. The challenge presented in our research was to correctly implement a progressive, intuitive categorization method to generate solutions, unifying individual proposals and ideas through a virtual platform or face-to-face sessions and real-time communication. This paper aims to present the implementation impact from students' first-use perceptions and experiences, segmented by study area, gender, and semesters. Our research began with creating an idea generation method. Experienced design professionals integrated various tools to run on digital platforms. This method was called ICRI, an acronym for Ideation, Categorization, Regrouping, and Ideation. The method had two primary stages. The initial stage employed four-step where the students defined, investigated, established findings, and formed teams to move on to the second stage. This second stage comprised two parts, the first four-step where students generated ideas, reviewed, defined, and grouped them; the second five-step process involved focusing the ideas for regrouping, discussion, fusion, and writing new ideas. This method was applied to start a product design process or design strategy to create a project design. The results revealed high student acceptance of the method due to its practicality, rapidity, and functionality in generating ideas and active, equitable student participation. We found that certain students' profiles are not optimistic about the use of such tools. Also, we found that there were no significant differences by gender of the student profile, but it was noted that female students liked the method more. The findings derived from the creation and application of the ICRI method were consequences of the need to create innovative practices to integrate higher education students. The ICRI method reinforces the trend of educational methods that address the relevance of collaborative idea generation and processes that facilitate effective interactions, even in a virtual and remote mode.

KEYWORDS

educational innovation, higher education, design, teamwork, ideas generation, professional education

1. Introduction

Currently, many professions must generate creative solutions, especially professions in the design process and other professions requiring creativity and innovation for new products, where ideas generation becomes of utmost importance (Ulrich and Eppinger, 2013; Gajda et al., 2017), both individually and in groups (Shubina and Kulakli, 2019). Therefore, ideas generation is a widely studied topic related to several factors determining its value in different contexts (Choi and Lee, 2015; Hutchinson and Tracey, 2015; Sarkar and Chakrabarti, 2017; Gonçalves and Cash, 2021). Ideas generation is connected to the creativity of individuals, which Ritter et al. (2012) define as creating something new, valuable, and highly appreciated in companies. However, several studies have shown that creativity and idea generation decrease through the years in higher education (Cheung et al., 2003), requiring a focus on observing the process and methods of idea generation in students or those who require it.

Generating ideas in an educational context is complex, this process involves unconscious and conscious thought (Ritter et al., 2012) and requires access to divergent memories and associations (Lacruz Rengel, 2013) and is associated with learning processes. Therefore, the person must have extensive knowledge of the subject and relate or associate the elements of that knowledge (Kilgour et al., 2020). According to Shah et al. (2000), there are two categories of formal methods for generating ideas: intuitive methods, which stimulate unconscious thought; and logical methods, which consider the analysis of the problem and its systematic decomposition through engineering and science cataloging, procedures, and solutions. The emphasis should be on intuitive methods subdivided into germinal, organizational, progressive, transformational, and hybrid classifications. In the 1980s, these categories had already been proposed but were considered with varying ideas and other independent problem elements (Wöhler and Reinhardt, 2021). Despite all this and the different solution development models available, professionals still have a limited understanding of how ideas are generated (Hutchinson and Tracey, 2015).

The relationship between the creative aspects of ideas and professional life is evident. There is a direct correlation between "idea generation for solutions" and "professional careers that resort to idea generation methods." For example, product design, industrial design, or similar careers depend on their culture and limit the generation of more ideas than desired or required (Lacruz-Rengel, 2008). An essential aspect of idea generation is the possibility of collaborative production and solutions that arise from a co-design process (Steen, 2013). This is important for companies because, in most cases, they form multidisciplinary teams to solve their problems or satisfy the needs of their clients holistically (Heslin, 2009; Ulrich and Eppinger, 2013). Several aspects are present in these multidisciplinary teams, people from various organizations or departments share knowledge and combine ideas (Steen, 2013). Also, cultural diversity in a team is positively related to individual and team creativity (Li et al., 2017). In this regard, the need to create working groups has evolved. Even in other professional fields like computational models have been developed that link the interactions of the participants as elements of a system; analyzing interventions that manipulate or control the different variables of the process (Vrgović et al., 2013; De Garrido et al., 2019). However, how far have the idea generating methods evolved? Innovations support methodologies to promote creativity and automate the control, direction, and documentation of the entire process in academics and companies (Herring et al., 2009; Drejeris, 2012; Tavanapour et al., 2019; Kilgour et al., 2020).

For example, in design-related professions in academia or companies, most of the time, solving complex problems must occur quickly; thus, idea generation has become a fundamental professional skill. Effectively, this happens mainly through multidisciplinary teams that include designers or creative professionals (Asante, 2018); however, it does not necessarily happen immediately when a complete idea generation process is started. Several actions are needed to begin a creative process, including gathering all information being developed (Kilgour et al., 2020). In a convoluted process, the union of creativity and the various perspectives of team members to generate solutions can be very complex (Steen, 2013). As mentioned above, this also exists in higher education environments (Law et al., 2013), where interactions, collaborative work, and participation become essential to creating a problem-solving tool. Likewise, students must respond to the creation of ideas and the follow-up of assessments and judgments by their teachers regarding the ideas' originality (Lacruz Rengel, 2013; Kilgour et al., 2020; Cotán et al., 2021). The relevance of creative methods focused on idea generation becomes relevant, particularly in many creative disciplines.

Hanington and Martin (2012), propose a classification of methods that focus on creative aspects, principally in the design process. These methods can be divided into five phases, namely: (1) Planning, scope, and definition; (2) Exploration, synthesis, and design implications; (3) Generation of concepts; (4) Evaluation, refinement, and production; (5) Launch and follow-up. These phases are linked to a generic structure within which the process of product design, service design, or simply problem-solving can be addressed (Ulrich and Eppinger, 2013). Exemplifying what the classification mentions, in the Concept Generation phase (3), methods such as Affinity Diagram, Cognitive Map, Conceptual Map, Generative Research, and Mental Model Diagrams stand out, whose general purpose is the generating new ideas or concepts, by considering the appreciations that have been made to define a situation or problem. Likewise, there are methods such as Brainwriting or Brainstorm Graphic Organizers, which contemplate, in addition to ideas generation, an organization, classification, or hierarchy of these, facilitating the analysis and selection of a final proposal (Hanington and Martin, 2012). On the other hand, there are alternatives with a wide scope of application such as Design Thinking, which involve different methods and assign a very significant value to the ideation or solutions generation (Brown, 2008).

Any of the methods mentioned above takes into consideration the use and performance in person, something that has been modified in recent years due to different factors. Presently, these changes are present in professionals' work where generate ideas in academic or industrial environments through face-to-face work groups or are moving to remote modalities supported by technology. In the transition to remote activities, the question has been raised as to which methods can coexist in their face-to-face or remote format. This research seeks to provide information in this regard since there are several examples of methods based on high-value technological resources that go beyond face-to-face meetings (employment training and teaching, for example) to enable activities to be performed virtually and remotely (Vrgović et al., 2013; Buisine et al., 2016). Evidence suggests that virtuality does not generate a problem if learning or dynamics are online and follow the same conditions (Cotán et al., 2021). Idea generation and their representations have happened remotely with success; since the last decade, collaborative work and idea generation have been supported by accessible technology (Klemmer et al., 2008; Jimenez-Narvaez and Segrera, 2011; Weibel et al., 2011). Undoubtedly, the evolution and changes found around idea generation, collaboration, and practice have led to a series of successes in recent years; however, in generating ideas, we can find other components that can determine a method's effectiveness (Hanington and Martin, 2012), many of these implications are due to interpersonal interactions.

The idea generation and the processes involved are tightly related to the interactions within the workgroups. In this context, studies and analyzes of the relationship between teams are presented (Lacruz-Rengel, 2008), in this relationship, there are components to highlight: the gender of the teams, inclusion, and contextual academic or industrial interactions. In this research, we will emphasize a particular component that is near to education and creative aspects. Studies show a correlation between gender and creative potential, evidencing positive relations in an individual approach (Shubina and Kulakli, 2019). Finding differences in the disposition to critical thinking among student groups with different degrees and genders has been the subject of exploratory studies (Walsh and Hardy, 1999). Mainly in higher education, students show representative behavior distinguished in gender, gender roles, and creativity; including common challenges for gender-diverse teams, where there are discrimination, communication problems, conflicts among team members, and low team cohesion (Santos et al., 2022). The results in other studies indicate that gender diversity is positively related to radical innovation, but it does not promote incremental innovation in the same way (Díaz-García et al., 2013). However, no problems have been found or indications within work teams related to gender and other aspects. This information gathering has given us indications that this research may present new information, as with other examples such as critical thinking during idea generation and creativity, no differences were found between semesters and gender (Zetriuslita et al., 2016) or relationships between gender and gender roles in creative dynamics (Stoltzfus et al., 2011; Alsos et al., 2013). Further indications indicate that in work groups, failures are not a gender element effect (Pearsall et al., 2008). According to Baer and Kaufman (2008), "there continue to be large gender inclusion differences in creative productivity, and these differences represent the most significant unanswered questions about gender and idea generation."

In conclusion, idea generation is a complex and vast process, and the workgroup dynamics and interaction determine nuances that may or may not affect the effectiveness of idea generation. Observing and studying the methods that generate ideas is relevant to providing students with the skills to consistently generate good ideas that help them overcome the creative and innovative challenges they face (Lacruz Rengel, 2013; Law et al., 2013; Hutchinson and Tracey, 2015). Therefore, this research exposes the implementation of an idea generation and integration method for undergraduate students in work groups in a multi-modality, simultaneously using two technological platforms. Due to the recent pandemic and the need to continue higher education studies in an online and hybrid format, this is a novel alternative for creative ideas generation at the higher education level in a presential and hybrid approach (virtual/face-to-face). In this research, our method brings several findings to focus on perception and experience, students' profiles, and gender perspectives regarding the experience of this method for managing and developing creative ideas.

2. Materials and methods

2.1. Participants

The participants were 138 students. The sample characteristics are described in Table 1. All student data were collected during the 2020–2021 semesters.

2.2. Methodology

2.2.1. ICRI method

This article presents the ICRI method (from the acronym "Ideation, Categorization, Regrouping, Ideation") to generate ideas and solutions. This method can be applied virtually through the MIRO® platform and Zoom® as a communication tool and as a hybrid where the team members are present, but the activity is conducted on the MIRO® platform (see Figure 1). The ICRI method is executed in the following steps:

2.2.1.1. Team formation

Students are organized into teams of 4 or 5 members (Cotán et al., 2021) to research a problem or problematic situation to identify the most critical aspects that must be considered when generating a solution (Lilien et al., 2002). The results of the investigation are presented in the form of findings, requirements, conditions, or more (Hanington and Martin, 2012; Ulrich and Eppinger, 2013).

2.2.1.2. Generation of individual ideas

Once the investigation results are defined, the students enter the MIRO® platform, where each team has a defined space to work. In that space, one of the team members writes the five or six most significant results (of the investigation) with the consensus of the whole team. Subsequently, each member of the team generates in writing 10 solutions to the problem, following the results of the investigation. The 10 ideas are recorded without receiving criticism from the team members and without considering the magnitude of the solution proposed to them (Vrgović et al., 2013; De Garrido et al., 2019; Kilgour et al., 2020), similarly to what happens in the Brainwriting method

TABLE 1 Sample characteristics.

Characteristics	Sample	*N*	Percent
Gender	Female	82	59.4%
	Male	56	40.6%
Career	Design	56	40.6%
	Architecture	15	10.9%
	Digital art	10	7.2%
	Music production	4	2.9%
	Social sciences	24	17.4%
	Engineering	29	21%
Semester	Semester 1–2	59	42.8%
	Semester 3–4	38	27.5%
	Semester 5–6	14	10.1%
	Semester 7–8	21	15.2%
	Semester 9	6	4.3%
How did you use the method?	Online (Miro + Zoom)	62	44.9%
	Hybrid (Classroom + Miro)	67	48.6%
	Presential (Post-its)	9	6.5%

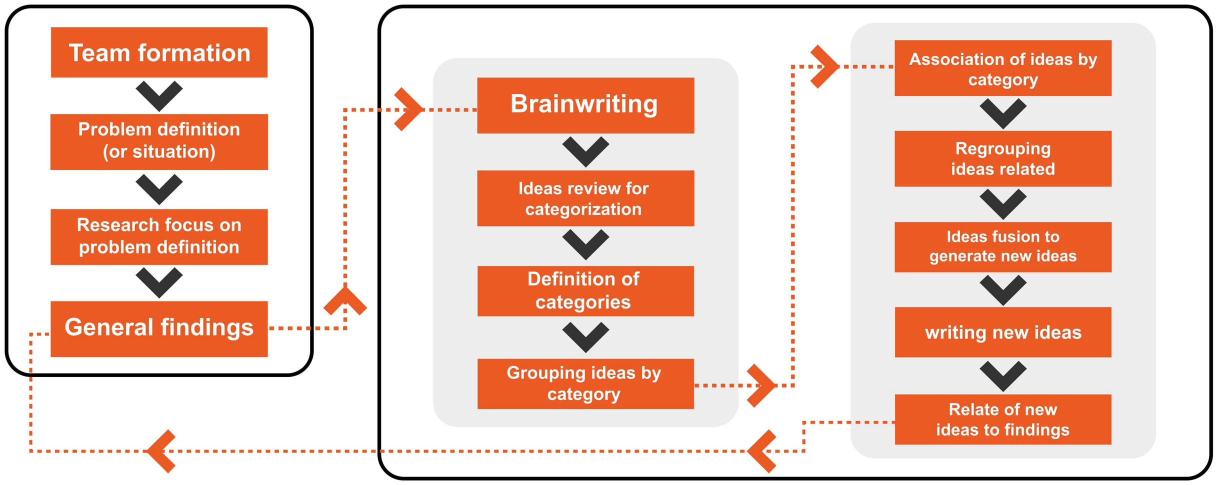

FIGURE 1
ICRI method diagram process.

(Shah et al., 2000). In this way, it is intended to minimize the domination of a team member, the effect of interpersonal conflicts that may exist, and the diversion of the main topic (Heslin, 2009).

2.2.1.3. Discussion of ideas

Once the idea generation is completed, all team members carefully read their colleagues' ideas to identify relevant aspects and similarities between all of them, and the connection with the problem.

2.2.1.4. Proposal of categories

After all team members review the ideas, they propose five or six categories that group the ideas similar to the Affinity Diagramming method (Hanington and Martin, 2012). The categories generated are considered concepts that house the ideas or are more related than others. This allows moving on to the next stage, which consists of regrouping the ideas per the category to which they belong or the one the team considers appropriate. When the ideas have been grouped into categories, new ideas or proposals begin to be generated, intuitively associating (Wöhler and Reinhardt, 2021) the individual ideas but taking at least one from each category. This association of ideas can take place by considering a base idea and adding others with attributes or new characteristics to represent a product, service, or system involving all the associated individual ideas. The method's new ideas or proposals generated from the association are rewritten in a single statement with a coherent description. They are related to the findings that resulted from the investigation and that were initially outlined to verify that the new ideas meet expectations.

2.2.2. Method implementation

The method was implemented for several semesters in different student groups (*classes*). As mentioned before in the participants' section, students belonged to different careers and semesters. The groups were students attending Tecnológico de Monterrey on two different campuses. The implementation began during the critical pandemic when education migrated to an online remote modality. The MIRO platform was used. As mentioned in the ICRI steps, when the students finished the entire research stage of their projects and had precise results obtained by working as a team (four or five members), they used the ICRI method. At this point, students were asked to enter the MIRO® platform, where they found a template previously established by the teacher with the essential sections to start the application. This template included a structure similar to that established for the Brainwriting method. It is noteworthy that up to this point and during the rest of the method's application, the students were not informed about its steps, but rather the teacher guided them step by step as they completed each activity.

2.2.2.1. Individual ideation stage

On the MIRO® platform, the students were asked to write about the most important findings of their research in a specific area. After this, each team member wrote 10 ideas to solve the problem (meeting the project requirements) in a column with *Post-it*-type colored squares, each identified at the top with their name and color choice for all the squares (see Figure 2). Although all team members could read what their classmates were writing, the teacher asked them not to criticize or comment on the ideas until this creative stage was over because most ideas were expected in the shortest possible time.

2.2.2.2. Categorization stage

Once the students finished the ideation part, each team member had to read their classmates' ideas to begin identifying possible categories. This activity requires students to discuss the ideas and generate agreements about the categories they will use or establish after analyzing them. After defining the categories, a team member duplicates all the ideas, which are grouped in the appropriate category (as shown in Figure 2). When the ideas have been regrouped in the categories, the same color is given to them, so their origin is intentionally lost to mitigate the effect of domination or interpersonal conflicts among the group members (Heslin, 2009).

2.2.2.3. Regrouping and new ideas stage

Once the previous categorization is finished, the students begin generating new ideas by intuitively associating one or more from each category without omitting any of them. This process is repeated several times, and discussion within the team is necessary to generate more

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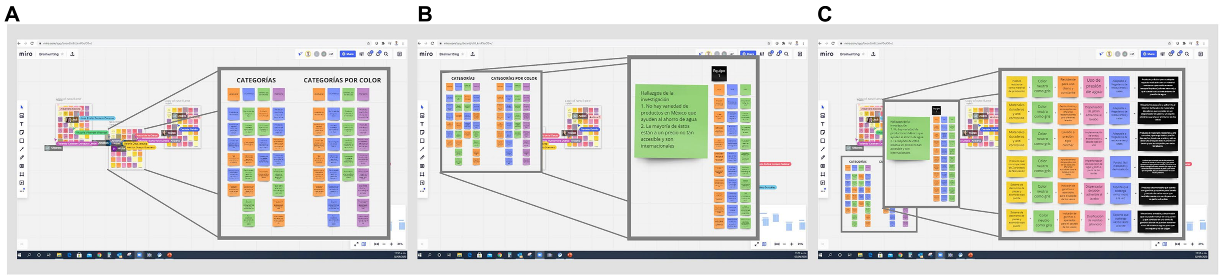

FIGURE 2
ICRI Method steps: **(A)** idea generation by one of the teams, **(B)** ideas grouped by categories and then differentiated with a different color per category, and **(C)** new proposals generated, building on the basic ideas developed previously.

coherent associations that could become complete proposals. The process is repeated until five or six new ideas are reached, which must be rewritten, linking all the individual ideas logically and credibly (see Figure 2). After this, each new proposal is verified for compliance with the research findings or project requirements. It is essential to clarify that individual ideas could be used in more than one of the new ideas, and there could also be more than one idea per category, as mentioned before, but omitting any of the categories was not allowed.

2.2.3. Method evaluation

At the end of the method, the students were surveyed to know their experiences and perception in their idea generation activity. These questions were designed based on previous work that assessed fundamental elements of this type of method and its approach. Also, a preliminary survey was already conducted to test its effectiveness (Canizares and Rojas, 2022). Fundamental aspects based on outcome considered the quantity, quality, novelty, and variety of ideas generated (Shah et al., 2000) and the method's relevance to the students (Smith, 1998).

We applied an online survey instrument with 6 relevant research questions; the other questions in the survey asked for demographic information. The six questions used a five-point Likert scale; the questions were:

- How much do you think this method allows the integration of ideas?
- How much do you think this method provides the same opportunity for participation by all team members?
- How much do you think this method allows you to generate appropriate solution proposals?
- How much do you think this method allows all teams to co-author proposals?
- How much do you consider this method easy and quick to generate good proposals?
- How much did you enjoy using the idea generation method?

3. Results

3.1. Statistical analysis

The results obtained from the online survey about experience and perception are described in Table 2. We divided the data into four analyzes to analyze the ICRI method in depth. A Kolmogorov–Smirnov normality test was applied to the data information, which showed it followed a normal distribution. The statistical method used for analyzes were univariate ANOVA and multivariate ANOVA (MANOVA) with Bonferroni correction. Statistical analysis was performed using SPSS for Windows™ (v.17.0, www.ibm.com/products/spss-statistics).

3.2. Perception-experience according to career

The results of the ANOVA for career factor with the six questions are described in Table 3. The test revealed that the six variables were statistically significant (value <0.05). Figure 3 shows plot representations of the means of the student's answers.

3.3. Perception-experience according to semester

The results of the ANOVA for the semester factor with the six questions are described in Table 4. The test revealed that one of the six variables presented a significant value (< 0.05). The "*How much did you enjoy using the idea generation method*?" question indicated a significant difference ($p = 0.05$). Figure 4 shows plot representations of the means of students' answers.

3.4. Perception-experience according to method application

The results obtained by the ANOVA for the method application factor with the six questions are described in Table 5. The test revealed that no variables presented a statistically significant value (< 0.05).

3.5. Perception-experience according to gender

The results of the ANOVA for gender factor with the six questions are described in Table 6. The test revealed that the six variables presented a statistically significant value (< 0.05). Figure 5 shows plot representations of the means of students' answers.

TABLE 2 Descriptive statistics for questions.

Questions	*N*	Mean	Std. deviation
How much do you think this method allows the integration of ideas?	138	4.44	0.684
How much do you think this method provides the same opportunity for participation by all team members?		4.61	0.739
How much do you think this method allows you to generate appropriate solution proposals?		4.33	0.728
How much do you think this method allows all teams to co-author proposals?		4.50	0.785
How much do you consider this method to be easy and quick to generate good proposals?		4.33	0.738
How much did you enjoy using the idea generation method?		4.31	0.809

3.6. Perception-experience according to gender and career

The results of the MANOVA for gender and career factor interaction with the six questions are described in Table 7. The test revealed four of the six variables had a statistically significant value with Bonferroni correction. The "*How much do you think this method provides the same opportunity for participation by all team members*?" question indicated a significant difference [F (1.986), $p = 0.085$] between factors. The "*How much do you think that this method allows you to generate appropriate solution proposals*?" question indicated a significant difference [F (3.019), $p = 0.013$] between factors. The "*How much do you think this method allows all teams to co-author proposals*?" question indicated a significant difference [F (1.708), $p = 0.138$]. The "How much do you consider this method to be easy and quick to generate good proposals?" question indicated a significant difference [F (2.715), $p = 0.010$]. Figure 6 shows plot representations for gender and career means.

4. Discussion

The ICRI method was designed as a consequence of virtual work in higher education necessitated by the pandemic. However, this dynamic led to educational innovation in the time and moment applied. Students received and perceived the method as good or excellent for idea generation and integration. Moreover, the method helped them generate and integrate multiples ideas and feel included. The sample results revealed significant information through this type of higher education dynamics. The results revealed much information that must be considered for applying this method type in education or as part of a creative disciplinary process to generate ideas to solve design challenges. Joia and Lorenzo (2021) declared that there is a need to develop creative methods, and understand the conditions and dynamics of classes in different contexts, in particular, our research contributes in virtuality mode (Zoom). The global evaluation of the method was positive. The results in Table 2 show that the students assessed the method positively, demonstrating that this method should be used whenever a generating and participation dynamic begins. According to Herring et al. (2009), an idea generation method should be simple and easy to use, in our case, in disciplines where problem-solving is required.

However, this research opened several questions about this educational innovation. If the method worked better for a particular student profile? As mentioned by Steele et al. (2018), generating creative ideas is a process that needs to be evaluated and observed, because it has a latent complexity in its reasoning (Lacruz Rengel, 2013). In our research, the general findings showed that the method's primary dimensions fulfilled its function in the multimodal context. A collaborative idea generation occurred, as a consequence of a co-design process (Steen, 2013). Thus, our students who completed the task of creating, collaborating, and grouping ideas collaboratively arrived at creative solutions. This process can be explained using the measurement elements of their perception of the experience of using the method. The following findings will be discussed here:

The ICRI method applied in different courses required a tool to generate ideas. The first characteristic observed was the students' careers. This opened the possibility of observing how the students' profiles could adopt the method and how they perceived it for the work assigned to them. Figure 3 shows the statistically significant means for these results. For the first question, "*How much do you think this method allows the integration of ideas*?" a closeness in answers can be seen between design ($m = 4.59$), social sciences ($m = 4.50$), and engineering ($m = 4.48$), followed by architecture ($m = 4.33$). However, digital arts ($m = 3.80$) and music production ($m = 3.75$) evaluated below the observed average mean. Thus, students in the latter two career profiles do not entirely agree that the method integrates ideas. However, design, social sciences, and engineering students agree. This is the first evidence of how a method works for specific profiles, as mentioned by Cheung et al. (2003). It is undeniable that discipline impacts the creative processes of undergraduate students. A similar effect is observed in the following two questions: "*How much do you think this method provides the same opportunity for participation by all team members*?" and "*How much do you think this method allows all team members to co-author proposals*?" In the first question, students in design ($m = 4.75$), social sciences ($m = 4.71$), and engineering ($m = 4.66$), followed by architecture ($m = 4.47$), shared the same thought, while music production (m = 4.00) and digital arts ($m = 3.90$) students did not. For the second question, design ($m = 4.70$), social sciences ($m = 4.48$), engineering ($m = 4.48$), and architecture ($m = 4.47$) students shared the same consideration, while music production ($m = 4.00$) and digital arts ($m = 3.90$) students once again did not. These questions reveal how a participatory method can be relevant and well perceived in student career profiles, but it does not directly refer to creative and non-creative disciplines. It can be due to a particular way of understanding challenge resolutions and participatory activities in career profiles that can create individual or participatory solutions. This agrees with what was reported by Pennington et al. (2021), that members of an interdisciplinary team might have difficulty sharing and combining knowledge with their peers. The next questions to be reviewed focusing on career profile

TABLE 3 Descriptive statistical and ANOVA for Career.

Questions	Career	N	Mean	Std. Dev	F	P
How much do you think this method allows the integration of ideas?	Design	56	4.59	0.532	3.533	0.005*
	Architecture	15	4.33	1.047		
	Digital art	10	3.80	0.789		
	Music production	4	3.75	0.957		
	Social science	24	4.50	0.511		
	Engineering	29	4.48	0.634		
How much do you think this method provides the same opportunity for participation by all team members?	Design	56	4.75	0.640	3.259	0.008*
	Architecture	15	4.47	1.125		
	Digital art	10	3.90	0.876		
	Music production	4	4.00	1.155		
	Social science	24	4.71	0.550		
	Engineering	29	4.66	0.553		
How much do you think this method allows you to generate appropriate solution proposals?	Design	56	4.45	0.570	4.695	0.001*
	Architecture	15	4.33	1.047		
	Digital art	10	3.70	0.483		
	Music production	4	3.25	0.500		
	Social science	24	4.25	0.794		
	Engineering	29	4.55	0.632		
How much do you think this method allows all teams to co-author proposals?	Design	56	4.70	0.685	2.810	0.019*
	Architecture	15	4.47	1.060		
	Digital art	10	3.80	0.789		
	Music production	4	4.00	1.155		
	Social science	24	4.46	0.721		
	Engineering	29	4.48	0.688		
How much do you consider this method to be easy and quick to generate good proposals?	Design	56	4.57	0.628	3.347	0.007*
	Architecture	15	4.27	1.100		
	Digital art	10	3.90	0.316		
	Music production	4	3.50	1.000		
	Social science	24	4.29	0.624		
	Engineering	29	4.21	0.726		
How much did you enjoy using the idea generation method?	Design	56	4.57	0.628	4.026	0.002**
	Architecture	15	4.00	1.000		
	Digital art	10	3.90	0.876		
	Music production	4	3.50	1.291		
	Social science	24	4.04	0.908		
	Engineering	29	4.45	0.632		

*The mean difference is significant at the 0.05 level.

were "*How much do you think this method allows you to generate appropriate solution proposals*?" and "*How much do you consider this method to be easy and quick to generate good proposals*?" For the question about appropriate solutions, engineering ($m = 4.55$) had the highest mean, followed by design ($m = 4.45$), architecture ($m = 4.33$), and social sciences ($m = 4.25$). Digital arts ($m = 3.70$) and music production ($m = 3.25$) had the lowest. However, for the question about easy and quick idea generation, similar means were presented in the career profiles of design ($m = 4.57$), social sciences ($m = 4.29$), architecture ($m = 4.27$), and engineering ($m = 4.21$), but digital arts (3.90) and music product ($m = 3.50$) had lower means. The results of these questions connect to how appropriate and fast the method can facilitate generating ideas. These results reveal that the student's career profile continues to influence the student's perception of this method of idea generation. Agreeing with described elements of ways of understanding idea generation methods (Shah et al., 2000; Hutchinson and Tracey, 2015). In the application of our method and the sample used: design, engineering, and architecture students assessed it the

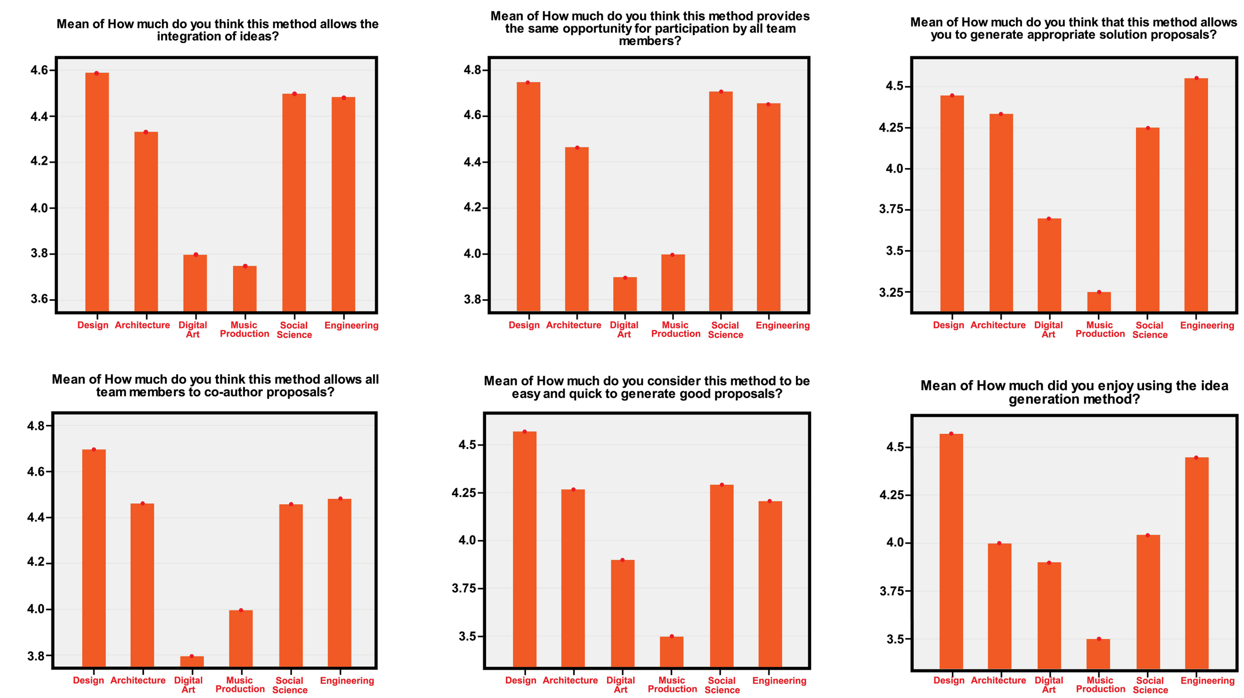

FIGURE 3
Plots of means for careers and perception-experience questions.

highest and digital arts and music production students the lowest. The preceding agrees again with what was mentioned by Cheung et al. (2003), in the sense that the field influences the creative processes, even if there were multiculturally aspects (Li et al., 2017), which can be good, but not all career profiles indicate the same experience. Finally, for the last question considered in the context of the students' career profiles ("How much did you enjoy using the idea generation method?"), the results were similar to the previously analyzed questions, where design ($m = 4.57$) and engineering ($m = 4.45$) students provided the best evaluation, followed by social sciences ($m = 4.04$), architecture ($m = 4.0$), digital arts ($m = 3.90$), and music product ($m = 3.50$). Although everyone generally enjoyed using the method, the design and engineering students principally were the ones assessing it as a better experience. It is also true that environmental factors and individual characteristics collectively affect the creative achievement of university students, as mentioned by Deng et al. (2016), but other aspects have to be better delimited in an investigation of this type.

Delving into students' perceptions, the second characteristic observed was the students' semester. As mentioned before, the ICRI method was applied in different courses that required a tool to generate ideas. Figure 4 shows the statistically significant means for these results. In this case, students' semesters can reveal information about their experience and perception of the method. For the question "*How much did you enjoy using the idea generation method*?" the results showed that the students in semesters 3–4 ($m = 4.55$), semesters 7–8 ($m = 4.48$), and semesters 5–6 ($m = 4.43$) enjoyed the method more than the students of semester 1–2 ($m = 4.08$) and semester 9 ($m = 4.17$). This subtle difference is relevant to how students experienced the method during a specific semester of their career education. The other questions did not reveal a difference between semesters, but we can observe that intermediate and last semester students seemed to be more aware of idea generation and related methods. Snyder et al. (2019) reported differences in student creativity throughout their undergraduate studies; our research showed the same. However, this does not limit the use of this method for the idea generation regardless of your semester. After the career and semester, a third characteristic was observed in the method applied in three modalities, with a significant effect to discuss. The results revealed no differences among students using the method online, hybrid, or presential. This finding is significant for this research, a similar experience and perception result positively. Our method can be applied according to the higher education need, online to presential. The ICRI method was born of necessity in a virtual modality; now, its effects can be extrapolated to presential to describe its impact and experience on students. This is consistent with the fact that hybrid learning is not systematically more or less effective than traditional classroom learning, as mentioned by Müller and Mildenberger (2021), and depends on the necessity. Face-to-face or remote technological support can be both valid alternatives (Vrgović et al., 2013; Buisine et al., 2016). This is one of the main findings that we can highlight in this research, this type of method can be differentiated from other methods (Hanington and Martin, 2012; Ulrich and Eppinger, 2013) because it can be used in different modalities.

After observing the student experience and perception by course, semester, and modality application, we were interested in knowing how the method was perceived per student gender. This last sample characteristic gave us relevant information about students' perceptions and experience of the ICRI method, adding our findings to many previously reviewed works about gender inclusion in idea generation. In these results, the student's opinions were different in each of the questions asked. The female valuation was higher than the male valuation. For the first question, "*How much do you think this method*

TABLE 4 Descriptive Statistical and ANOVA for Semester.

Questions	Semester	N	Mean	Std. Dev	F	P
How much do you think this method allows the integration of ideas?	Semester 1–2	59	4.32	0.797	1.693	0.155
	Semester 3–4	38	4.66	0.534		
	Semester 5–6	14	4.36	0.497		
	Semester 7–8	21	4.38	0.669		
	Semester 9	6	4.67	0.516		
How much do you think this method provides the same opportunity for participation by all team members?	Semester 1–2	59	4.44	0.97	2.084	0.086
	Semester 3–4	38	4.79	0.413		
	Semester 5–6	14	4.79	0.426		
	Semester 7–8	21	4.52	0.602		
	Semester 9	6	5	0		
How much do you think this method allows you to generate appropriate solution proposals?	Semester 1–2	59	4.27	0.784	0.999	0.411
	Semester 3–4	38	4.34	0.708		
	Semester 5–6	14	4.21	0.699		
	Semester 7–8	21	4.43	0.676		
	Semester 9	6	4.83	0.408		
How much do you think this method allows all teams to co-author proposals?	Semester 1–2	59	4.37	0.927	2.43	0.074
	Semester 3–4	38	4.76	0.431		
	Semester 5–6	14	4.5	0.855		
	Semester 7–8	21	4.29	0.784		
	Semester 9	6	4.83	0.408		
How much do you consider this method to be easy and quick to generate good proposals?	Semester 1–2	59	4.25	0.801	2.23	0.051
	Semester 3–4	38	4.55	0.602		
	Semester 5–6	14	4.5	0.65		
	Semester 7–8	21	4	0.707		
	Semester 9	6	4.5	0.837		
How much did you enjoy using the idea generation method?	Semester 1–2	59	4.08	0.877	4.442	0.050*
	Semester 3–4	38	4.55	0.795		
	Semester 5–6	14	4.43	0.514		
	Semester 7–8	21	4.48	0.68		
	Semester 9	6	4.17	0.753		

*The mean difference is significant at the 0.05 level.

allows the integration of ideas?" female students ($m = 4.59$) opined higher than male students ($m = 4.23$). For the question "*How much do you think this method provides the same opportunity for participation by all team members*?" the same effect was observed where female students ($m = 4.59$) exceeded the opinion of male students ($m = 4.45$). In the following questions, the distance in the means is more evident. The "*How much do you think that this method allows you to generate appropriate solution proposals*?" question had means of female ($m = 4.50$) and male ($m = 4.09$). The "*How much do you think this method allows all team members to co-author proposals*?" question resulted in female ($m = 4.68$) and male ($m = 4.23$) means. The "*How much do you consider this method to be easy and quick to generate good proposals*?" question provided female ($m = 4.49$) and male ($m = 4.11$) means, and the "*How much do you consider this method suitable for integrating individual ideas with those of a team*?" question had a female ($m = 4.73$) and male ($m = 4.21$) means. Finally, the "*How much did you enjoy using the idea generation method*?" question revealed a statistically significant difference. The females ($m = 4.48$) enjoyed it much more than the males ($m = 4.07$).

Exploring gender perception is part of the contribution to the acceptance of a method, either because it can be used for any student or because it can be a motivational tool. In either case, understanding gender perception is a research topic that can be further explored. These findings, as mentioned before, put in evidence the experience and perception of women students with a higher impact from the methodology than male students. Idea generation and participatory methods have been discussed several times as crucial dynamics, and this method reveals a positive experience and perception in the woman sample. A method with a gender inclusion perspective contributes to idea generation, as mentioned by Li et al. (2017); diversity and inclusion positively influence the creativity of multicultural teams. It is important to note that participatory methods

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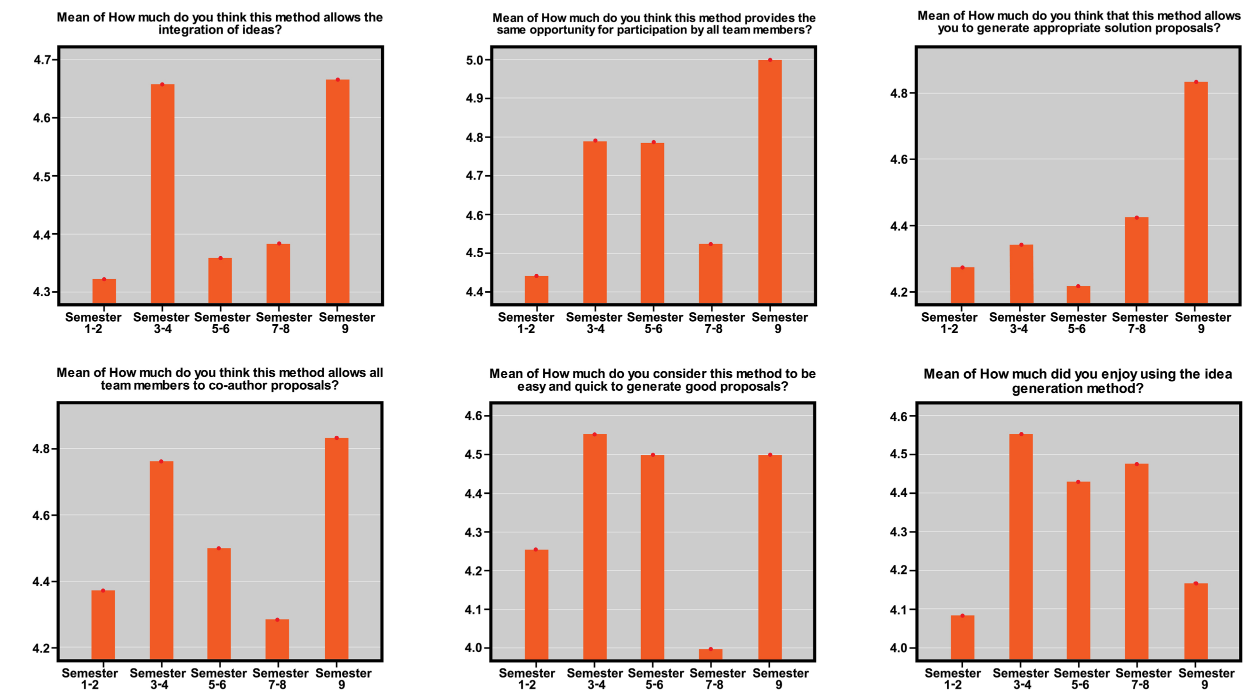

FIGURE 4
Plots of means for semesters and perception-experience questions.

TABLE 5 Descriptive statistical and ANOVA for method application.

Questions	Application	N	Mean	Std. Dev	F	P
How much do you think this method allows the integration of ideas?	Online (Miro + Zoom)	62	4.45	0.67	0.121	0.886
	Hybrid (ClassRoom + Miro)	67	4.45	0.702		
	Presencial (Post-its)	9	4.33	0.707		
How much do you think this method provides the same opportunity for participation by all team members?	Online (Miro + Zoom)	62	4.44	0.783	0.469	0.627
	Hybrid (ClassRoom + Miro)	67	4.52	0.705		
	Presencial (Post-its)	9	5	0.726		
How much do you think this method allows you to generate appropriate solution proposals?	Online (Miro + Zoom)	62	4.39	0.662	0.534	0.587
	Hybrid (ClassRoom + Miro)	67	4.27	0.79		
	Presencial (Post-its)	9	4.44	0.726		
How much do you think this method allows all teams to co-author proposals?	Online (Miro + Zoom)	62	4.42	0.841	0.712	0.492
	Hybrid (ClassRoom + Miro)	67	4.58	0.742		
	Presencial (Post-its)	9	4.44	0.726		
How much do you consider this method to be easy and quick to generate good proposals?	Online (Miro + Zoom)	62	4.27	0.682	0.395	0.675
	Hybrid (ClassRoom + Miro)	67	4.37	0.795		
	Presencial (Post-its)	9	4.44	0.726		
How much did you enjoy using the idea generation method?	Online (Miro + Zoom)	62	4.31	0.692	0.13	0.878
	Hybrid (ClassRoom + Miro)	67	4.3	0.905		
	Presencial (Post-its)	9	4.44	0.882		

*The mean difference is significant at the 0.05 level.

should be designed to be a similar experience for everybody. If we can ensure that a method works the same for everyone, the participation of all people can equally impact the creativity of ideas (Bart et al., 2015; Shubina and Kulakli, 2019). Finally, a last observation was made with the data obtained from the research. After observing all the sample characteristics, we decided to observe two characteristics for more information about the students' perceptions and experiences using the ICRI method. The final observation was made by looking at

TABLE 6 Descriptive statistical and ANOVA for GENDER.

Questions	Gender	N	Mean	Std. Dev	F	P
How much do you think this method allows the integration of ideas?	Female	82	4.59	0.543	9.429	0.003*
	Male	56	4.23	0.809		
How much do you think this method provides the same opportunity for participation by all team members?	Female	82	4.72	0.653	4.662	0.033*
	Male	56	4.45	0.829		
How much do you think this method allows you to generate appropriate solution proposals?	Female	82	4.50	0.550	11.385	0.001*
	Male	56	4.09	0.880		
How much do you think this method allows all teams to co-author proposals?	Female	82	4.68	0.683	11.829	0.001*
	Male	56	4.23	0.853		
How much do you consider this method to be easy and quick to generate good proposals?	Female	82	4.49	0.614	9.389	0.003*
	Male	56	4.11	0.846		
How much did you enjoy using the idea generation method?	Female	82	4.48	0.652	8.784	0.004*
	Male	56	4.07	0.951		

*The mean difference is significant at the 0.05 level.

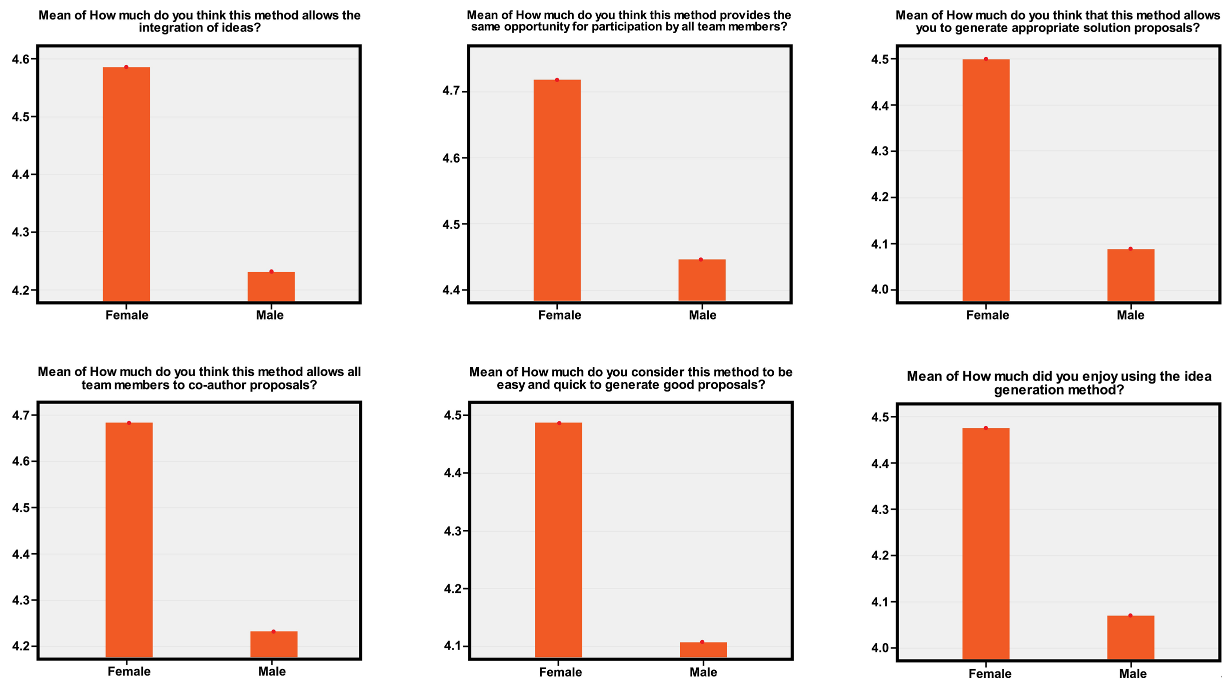

FIGURE 5
Plots of means for gender and perception-experience questions.

gender and career. This interaction showed significant differences in method perception and experience. We focused on the higher assessments to observe the effects in this sample segmentation. The first question analyzed was "*How much do you think this method provides the same opportunity for participation by all team members*?" where design ($m_{female} = 4.76$) and engineering ($m_{female} = 4.82$) females were the two highest, in contrast to their counterparts, design ($m_{male} = 4.73$) and engineering ($m_{male} = 4.56$). The second question reviewed was, "*How much do you think that this method allows you to generate appropriate solution proposals*?" Engineering ($m_{female} = 4.73$) and social sciences ($m_{female} = 4.64$) females were the two highest, in contrast to their male counterparts in Engineering ($m_{male} = 4.44$) and design ($m_{male} = 4.40$). The third question examined was, "*How much do you think this method allows all team members to co-author proposals*?" Social sciences ($m_{female} = 4.82$) and design ($m_{female} = 4.76$) females were the two highest, in contrast with males in design ($m_{male} = 4.40$) and engineering ($m_{male} = 4.44$). The last question observed was, "*How much do you consider this method to be easy and quick to generate good proposals*?" Design ($m_{female} = 4.59$) and architecture ($m_{female} = 4.58$) females were highest, in contrast with

TABLE 7 Statistical result of multivariable ANOVA (MANOVA) for independent variables for questions.

Questions	SS	dF	MS	*F*	*p*
Gender*Career					
How much do you think this method allows the integration of ideas?	2.490	5	0.498	1.249	0.290
How much do you think this method provides the same opportunity for participation by all team members?	4.699	5	0.940	1.986	0.085[a]
How much do you think this method allows you to generate appropriate solution proposals?	6.037	5	1.207	3.019	0.013[b]
How much do you think this method allows all teams to co-author proposals?	4.498	5	0.900	1.708	0.138[c]
How much do you consider this method to be easy and quick to generate good proposals?	7.057	5	1.411	2.715	0.010[d]
How much did you enjoy using the idea generation method?	2.305	5	0.7461	0.817	0.540

[a]*R* Squared = 0.215 (Adjusted *R* Squared = 0.147), [b]*R* Squared = 0.204 (Adjusted *R* Squared = 0.134). [c]*R* Squared = 0.214 (Adjusted R Squared = 0.146), [d]*R* Squared = 0.214 (Adjusted *R* Squared = 0.146).

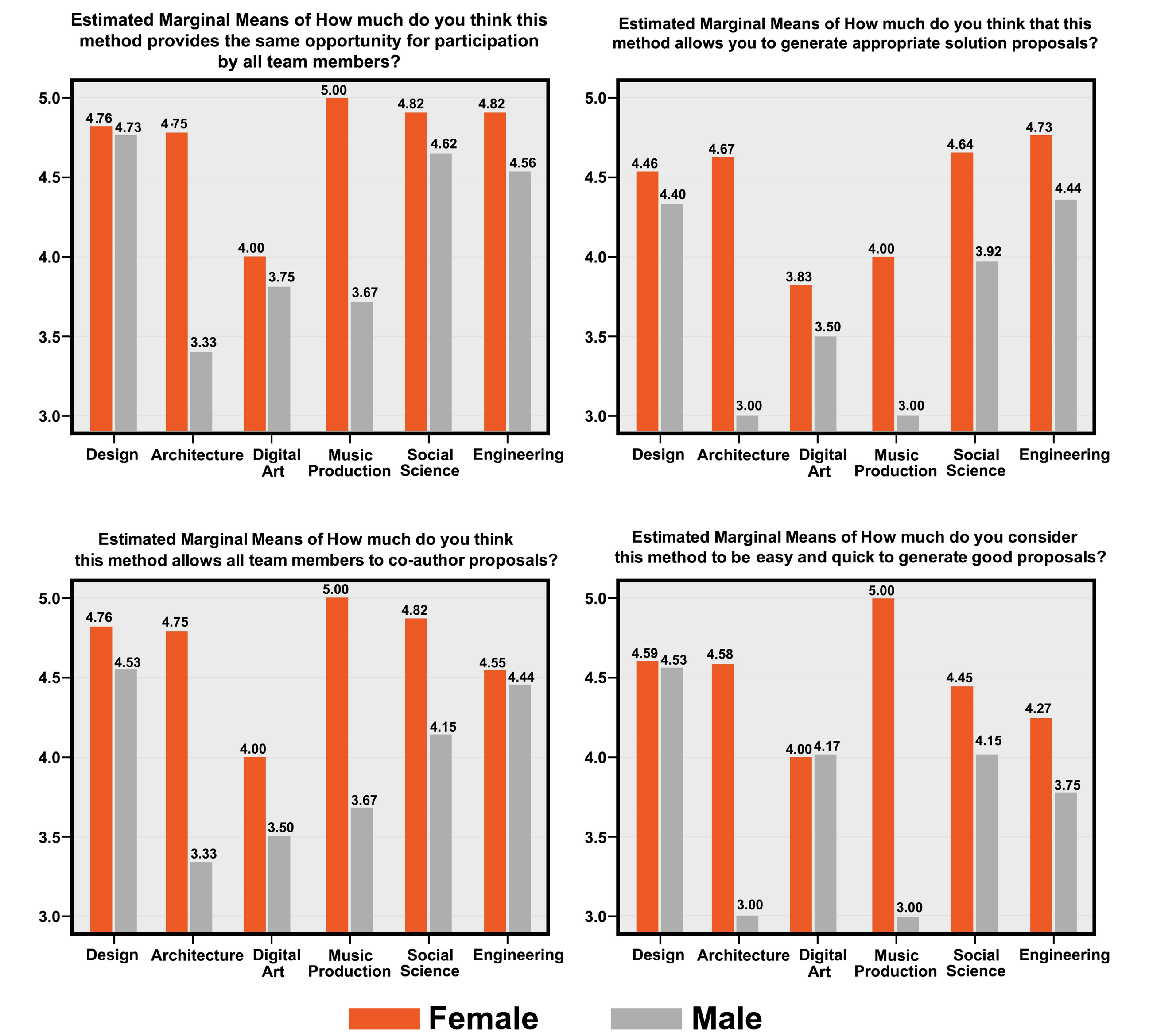

FIGURE 6
Plots of means for gender-career and perception-experience questions.

males in design (m_{male} = 4.53) and engineering (m_{male} = 4.17). The findings of this last analysis only supported what had already been explored in previous observations. The female students had better impressions and perceptions according to their answers, in contrast to the male students, even in the same career. This further ensures the relevance of applying these methods in any career and gender context. Additionally, in conjunction with career profiles, women in careers who need problem-solving tools assessed the method better than men. This knowledge adds to several things that Alsos et al. (2013), Zetriuslita et al. (2016), and Stoltzfus et al. (2011) mentioned about gender not affecting work and idea generation in creative productivity.

Finally, all the findings of this research give us more information on the perception of this educational innovation proposal, however, we must warn of certain limitations that were also detected. Two important limitations must be considered to incorporate the ICRI method in further studies. First, the method application must contemplate the situation or problem to be solved, the method is mainly conditioned to solutions focused on products, services, experiences, etc. However, it should not be limited to this, but more sample groups and punctuated problem-solving situations are needed. Second, the method's efficacy needs to be validated by similar activities with a control group in order to further investigate the use of the method. The sample to be used can be further refined by student profile and demographics of interest. The capture instrument (survey) can be further refined by adding more demographic and interest information. However, the dynamics within the classroom are complex for the selection of a sample to be specific.

5. Conclusion

The development of the ICRI method resulted from the changes necessitated by the need for virtuality in higher education due to the pandemic. The students' perception and experience of the method indicate that its implementation can be seen as an educational innovation because it was very well accepted, principally in women's experiences. In addition to the above, the ICRI method helped students generate many ideas in a virtual context, giving a systemic response to the problematic situations that the students faced when gathering, developing, and selecting ideas and creative proposals as a team. Above all, the main findings highlighted women's positive perception and experience in design, engineering, and architecture, where they appreciated the integration of ideas and the method's relevance. These outcomes revealed fairness and parity in idea generation and student collaboration. Similarly, the students considered the ease and speed of the method adequate, which invites them to use it again. Unfortunately, we found that careers such as digital arts and music production had a lesser agreement with the method or the aspects surrounding idea generation and its usefulness in their professional activities.

The ICRI method reinforces the trend of educational methods that address the importance of generating ideas collaboratively, and having processes that facilitate effective interactions, even virtually and remotely, as the circumstance of recent years promotes. On the other hand, based on the findings of this research, the positive evaluation of the students suggests that the ICRI method is considered an innovative tool for idea generation at the higher education level, aligning with similar method dynamics, students appreciate the opportunity to reuse the method to solve a challenge under any future conditions. In conclusion, we emphasize that this research is the starting point of a series of observations that will add more findings as more students use the ICRI method. As mentioned above, there are opportunities to delve deeper into motivational, cultural and personality aspects of the students. This first interaction uncovered areas for improvement concerning moments in the method's steps. We must document and create evidence regarding how some of the work moments occur. For example, what is the process of combining ideas in each category? Furthermore, this research can establish more limited sample observation parameters for observing and measuring the method's impact on equitable and similar characteristics (for example, samples outside of creative industries or engineering). Finally, with the limitations or advantages of technology, the ICRI method must develop and implement other resources that allow maximizing its attributes, considering the possibility of implementation in other contexts and the opportunity for future work with this research.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

All authors contributed to the article and approved the submitted version. JCMC designed the study and supervised the whole study. J-CR conducted the statistical analyzes. AA supported with implemented sample. All authors assisted in write, revision process, read, and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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