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Design Thinking as a Co-Creation Methodology in Higher Education. A Perspective on the Development of Teamwork and Skill Cultivation

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Abstract: Graduates of higher education need, in addition to knowledge, skills such as cooperation, communication, and problem-solving to cope with their working life. Collaborative learning environments like co-creation, are gaining attention for their ability to cultivate these essential skills. This study aims to investigate the understanding and efficacy of co-creation from the perspective of 145 undergraduate students enrolled in a physics course, using a questionnaire. Design thinking, using the double-diamond model, is applied as the co-creation methodology. The study examines the effects of co-creation and design thinking on teamwork and the development of skills. The study also discusses the differences in co-creation, design thinking, teamwork, and skill development among various demographics, previous co-creation experiences, and teaching methods. The findings demonstrate that the majority of students understand the concepts of co-creation and design thinking, and that their co-creation teams functioned satisfactorily, leading to the development of necessary skills. However, increasing age seems to be an inhibiting factor. Finally, the study shows that students who prefer co-creation as a teaching method or have previous co-creation experiences are more receptive to this approach.

Keywords: *Co-creation, design thinking methodology, skills, teamwork, university students.*

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Introduction

In recent years, significant changes have been observed in teaching methods in higher education. Teaching is no longer solely focused on academic staff members, but instead emphasizes student-centred teaching and active learning (Gibbs, 1995; Lempert, 1996), with a focus on engagement and student involvement (Kuh, 2008; Kuh et al., 2010; Lattuca & Stark, 2009). In the last decade, co-creation, has become a crucial element of teaching, considering students as partners in learning and teaching (Cook-Sather et al., 2014; Dunne, 2016; Healey et al., 2016; Mercer-Mapstone et al., 2017).

According to Bovill et al. (2016), co-creation is the space between students' engagement and collaboration, creating meaningful collaboration with their professors. Student participation in university co-creation varies and includes providing information, consulting, research involvement, partnerships, and initiative leading (Bovill, 2017; Könings et al., 2017). The students may adopt a variety of responsibilities, acting as advisors, representatives, co-researchers, and co-designers (Bovill et al., 2016). The main goal of co-creation is to bring together the different perspectives of stakeholders, to eventually find common ground (Grönroos, 2011; Marquis et al., 2017).

However, participation becomes more complex when student groups are large, especially if the groups do not function as expected and resist active participation or co-responsibility (Bovill, 2020). Students often express reluctance to engage in co-creation, preferring a more passive role or feeling a lack of ownership of the work produced. Also, their participation may be constrained by time limitations and heavy workloads, as they prefer to spend time on personal targets (Bovill et al., 2011; Carey, 2013; Martens et al., 2020). Additionally, students feel insecure about their knowledge and skills, especially when co-creation requires them to think "outside the box" with unfamiliar content and no pedagogical expertise (Bovill et al., 2016; Brown, 2019).

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The authors used the double-diamond design thinking methodology as a co-creation approach (Design Council, 2007) to introduce the students in a methodical and organised way to develop ideas that will contribute to meeting real needs. The double-diamond has been successfully applied to manage planning and innovation processes in management and marketing (Davis et al., 2016; Malakhatka et al., 2021; Payne et al., 2008; Sanders & Stappers, 2008). The model consists of four design process phases: discover, define, develop, and deliver. It starts with an initial idea and ends with the delivery of a product or service (Design Council, 2007). The double-diamond approach involves divergent thinking through the discover and develop phases, during which diverse ideas are generated and explored, followed by convergent thinking through the define and deliver phases, during which the concepts are defined (Design Council, 2007). The problem definition phase is situated in the first diamond, while the exploration of viable solutions through the design process is located in the second diamond. The concepts and prototypes in this diamond are finalised based on stakeholder feedback and observations (Dos Santos et al., 2018).

Co-creation has been implemented through various approaches at all levels of higher education (Bovill, 2020; Bovill et al., 2010; Clothier & Matheson, 2019; Riva et al., 2022). On the other hand, design thinking is mainly related to skills in educational environments such as collaboration, creativity, and problem solving (Guaman-Quintanilla et al., 2022). Nevertheless, in the literature, there is a lack of evaluation of the results of the design thinking approach (Liedtka, 2014) as well as an absence of statistically strong empirical studies on its effectiveness (Spee & Basaiawmoit, 2016). However, this paper uses the double-diamond design thinking approach as a co-creation methodology, to explore the impact of both concepts in a university environment, contributing to the relevant literature. The study focuses on three main aspects: (a) the understanding of the concepts of co-creation and design thinking; (b) the context of a co-creation group; and (c) investigating the skills developed through this context by the 145 undergraduate students in a university-level physics course. The research results, limitations, and future approaches are presented.

Literature Review

Design Thinking

The concept of design thinking, which "uses the sensibility and methodologies of the designer to match people's demands with what is technologically achievable and what a viable business strategy can turn into customer value and market potential," design thinking can be summed up (Brown, 2009, p.86). The university educational framework is attributed to design thinking methodology characteristics such as solving ill-defined problems, human-centred approach, collaboration, and creativity (Ito et al., 2015; Lugmayr et al., 2014; Patel & Mehta, 2017; Wrigley & Straker, 2017). To implement the design thinking methodology, researchers have suggested various approaches, including the double-diamond used in this research, which was proposed by the UK Design Council (Design Council, 2007).

Teamwork

The context in which a co-creation team operates is vital in enabling it to complete its assigned task. Additionally, teamwork is essential for design thinking (Camacho, 2018). According to Panke (2019), one of the advantages of applying design thinking in education is to encourage teamwork. The diversity of opinions among group members leads to the development of ideas that meet the needs of various stakeholders. However, great diversity can increase the process's complexity, leading to conflicts between team members (Edmondson & Nembhard, 2009; Pera et al., 2016). Achieving a common goal is a challenging process, given the differences between goals and individual expectations (Roosens et al., 2018). Communication in various forms, especially interpersonal, contributes significantly to exchanging information and creating ideas between its members (Katz, 1982).

Development of Skills

In co-creation, students transition from passive recipients to active agents, shaping even simple completion of learning tasks into the acquisition of metacognitive awareness (Baxter-Magolda, 2006; Cook-Sather et al., 2014). As a result, the students develop essential skills such as communication, teamwork, and leadership (Cook-Sather et al., 2014; Lubicz-Nawrocka, 2017). In addition, academic staff create a learning environment that encourages students to share their views, experiences, and alternative perspectives, empowering them to become active members of their learning community and active citizens in a democratic society beyond the classroom (Bron et al., 2016).

However, in the design thinking literature, abilities like creativity are described either as abilities that are acquired through the process (Alhamdani, 2016; Clemente et al., 2017) or as characteristics of the methodology (Lewrick et al., 2020). According to Voss and Post (1988) and Jonassen (1977), students must possess the capacity for critical thinking to work with natural and ill-defined problems, which is one of the hallmarks of design thinking.

Methodology

Research Design

This work aims to enhance students' understanding of the concepts of co-creation and design thinking, primarily by exploring how the co-creation team works and the skills that are developed. 145 students from the Department of Industrial Design and Production Engineering of the University of Western Attica, a public university, voluntarily participated and completed the physics course with co-creation.

Initially, training sessions were conducted by the professor on qualitative and constructive feedback, expressing students' viewpoints in discussions, leadership skills, and conflict resolution, according to Geraghty et al. (2020), Jensen and Bennett (2016), and Stalmeijer et al. (2016). The specific students had sufficient conditions to complete the approach (Vardakosta et al., 2022).

The students were arbitrarily divided into 25 groups of 5 to 6 individuals, based on Stewart's (2006) finding that a project group should ideally have fewer than seven members. Each team was tasked with using the double-diamond design thinking model to find a solution to a real problem. The problems were different for each group and based on modules in the physics course, specifically electromagnetism. Students applied specific techniques and tools at each stage of design thinking with guidance from their professor. For the discovery phase, the tools used, among others, were interviews, diary studies, observations, extreme and mainstream users, and journal databases. For the definition phase, tools such as the customer journey map, the stakeholders map, the synthesis wall, the decision matrix, and SWOT analysis. For the development phase, tools were used such as the round robin, scenarios, the paper and cardboard mock-ups, involving users and the feedback loops. For the delivery phase, the tools used were the final testing, scenarios and tasks, quality testing, iterative refinement, storytelling, elevator pitch, and the sustainability plan.

All 25 groups of students, in collaboration with their professor, scheduled meetings twice a week to present the techniques and tools they had learned, as well as the progress of their work. In turn, fellow students added comments and suggestions to improve the quality of the work and correct any errors. According to Asikainen et al. (2014) and Herrmann et al. (2017), peer support encourages student learning, constructive feedback, and less alignment in teaching. The professor instructed each group to have frequent meetings among its members to discuss and evaluate workable solutions to the problem they were asked to solve.

At the end of the semester, the students presented their work to the class and were evaluated by their professor. Subsequently, the students filled out a questionnaire that, included four sections: co-creation, design thinking, group functioning, and skills developed through co-creation. The questionnaire also requested demographic information, such as gender identity, age, and year of study. The four sections of the questionnaire consisted of closed-type questions on a five-point Likert scale (ranging from "not at all" to "very much"), as well as multiple-choice questions (see Appendix). Additionally, open-ended questions were included on the definitions of co-creation and design thinking, as well as the usefulness of solving real-world problems as part of the course.

Sample and Data Collection

In the spring semester of 2020-21, the students completed an anonymous survey using Microsoft Forms. The survey yielded feedback from all 145 students, which was then exported in ASCII format for further use. The feedback received was anonymous comments.

Analysing of Data

The statistical analysis was performed utilising SPSS version 28 software, and encompassed a variety of analytical approaches. Firstly, descriptive statistics were applied to investigate the variables of co-creation, design thinking, teamwork, skills development, as well as demographic variables including gender identity, age, and year of study. This analysis further covered the questionnaire questions R1-R25, facilitating a thorough evaluation of the data.

In addition, the ANOVA test was employed to identify any significant relationships between the variables and the students' gender identity, age, and year of study. Moreover, the t-test was implemented to ascertain whether a significant correlation existed between variables, such as previous experiences in co-creation and teaching methods. Finally, the X^2 test was employed to investigate the relevance of categorical variables, such as previous experiences in co-creation and teaching methods, and solving real problems in a course, to gender identity. By utilising these rigorous analytical methods, we were able to obtain a comprehensive understanding of the relationships and correlations between the various variables, ultimately enabling us to draw meaningful conclusions from the data.

The qualitative questions were subjected to an inferential analysis, which involved examining the responses in the context of the research question and the study objectives. This analysis aimed to identify underlying themes, patterns, and meanings in the students' answers, which could provide insight into their perspectives, experiences, and attitudes towards the study topic. The analysis involved a systematic and rigorous process of coding and categorizing the data, using a grounded theory approach to develop new insights and theories from the data itself. Through this approach, the

study sought to move beyond the surface-level descriptions of the responses and to uncover deeper insights into the students' views and experiences. The findings from this analysis can provide valuable information for understanding the factors that contribute to effective co-creation and design thinking processes, as well as for developing strategies to improve these processes in educational contexts.

Table 1. Cronbach's Alpha and Number of Items for Various Scales

	Cronbach's Alpha	N of Items
Co-Creation	.653	5
Design Thinking	.840	2
Teamwork	.736	10
Skills	.911	8

Table 1 shows the Cronbach's alpha coefficient and number of items for four scales: co-creation, design thinking, teamwork, and skills. Cronbach's alpha is a measure of internal consistency reliability, which indicates the degree to which items within a construct are related to each other. The coefficient ranges from 0 to 1, with higher values indicating greater internal consistency.

The results indicate that skills have the highest Cronbach's alpha value of .911, indicating high internal consistency among the 8 items that measure this construct. Design Thinking has a relatively high coefficient of .840, indicating good internal consistency among the 2 items that measure this construct. Co-creation has a lower coefficient of .653, indicating lower internal consistency among the 5 items that measure this construct. Teamwork also has a moderate coefficient of .736, indicating moderate internal consistency among the 10 items that measure this construct. Therefore, the results of the Table 1 indicate that the four scales (co-creation, design thinking, teamwork, and skills) have relatively high internal consistency.

The strategy of sampling was used to ensure that the analysis was reliable. It involved selecting a sufficient number of participants (n>30) that were representative of the target population. This ensured that the findings could be generalized to the population of interest. A larger sample size typically resulted in a more representative sample and could increase the reliability of the analysis. At this point, it is worth noting that there were 145 participants. However, as 3 individuals did not provide a clear answer regarding their gender, they were excluded from the sample. Therefore, the analysis will continue with a sample size of 142 individuals.

Additionally, random sampling techniques could be used to ensure that each member of the population had an equal chance of being included in the sample. By selecting participants in this manner, it could help to reduce bias and increase the likelihood of obtaining a representative sample. Therefore, the use of appropriate sampling techniques was deemed critical in ensuring the reliability and validity of qualitative data analysis.

It was important to ensure that research data met the assumptions of the statistical techniques used for analysis. Various tests and checks could be performed to ascertain this, depending on the nature of the data and analysis. Normality tests, such as the Shapiro-Wilk, Kolmogorov-Smirnov, and Anderson-Darling tests, were commonly used to assess whether the data were normally distributed. Homoscedasticity tests, such as Levene's, Bartlett's, and Brown-Forsythe tests, assessed whether the variances of the data were equal across different groups or conditions. Additionally, independence tests were used to assess whether the data points were independent of each other.

Results

Descriptive Data Analysis

Table 2. Gender Identity and Age Distribution of Participants

		N	%
Gender Identity	Women	50	35.2%
	Men	92	64.8%
	Total	142	100.0%
Age	18-20	124	87.3%
	21-22	14	9.9%
	>23	4	2.8%
	Total	142	100.0%

The Table 2 shows the gender distribution of the sample group with a total of 142 participants. Out of the total sample, 64.8% (92) identified as male, while 35.2% (50) identified as female.

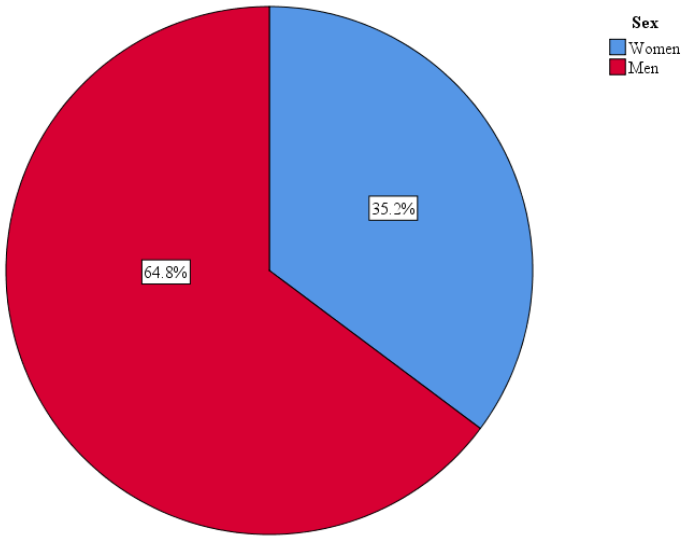

Figure1. Pie Chart for Gender Identity

Moreover, the Table 2 presents the distribution of responses to the question "What is your age?" from a sample of 142 participants. The majority of respondents (87.3%) were aged between 18 and 20 years old. Only a small percentage of respondents (9.9%) were aged between 21 and 22 years old, while an even smaller percentage (2.8%) were over the age of 23.

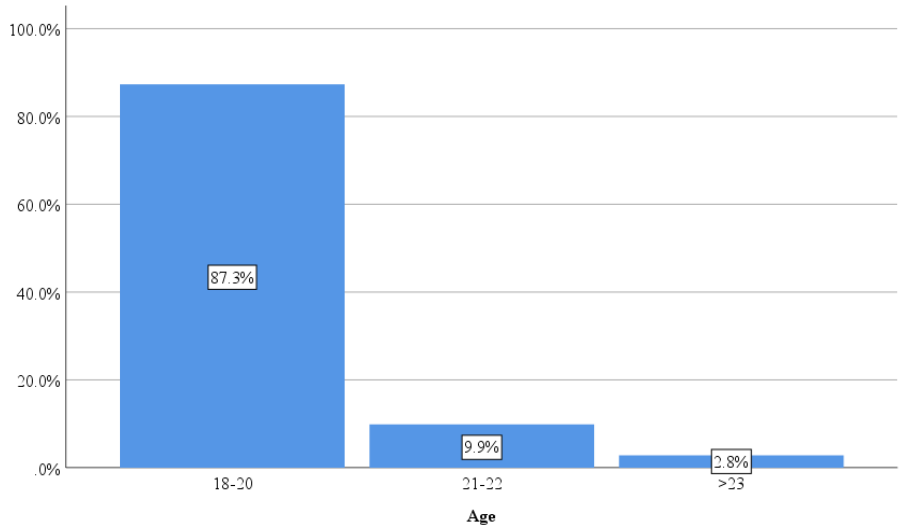

Figure 2. Chart for Age

Table 3. Year of Study Distribution of Participants

		N	%
What is your year of study?	1st year of study	125	88.03%
	2nd year of study	4	2.82%
	3rd year of study	8	5.63%
	4th year of study	1	0.7%
	5th year of study	4	2.82%
	Total	142	100.0%

In the Table 3 above, the distribution of responses to the question "What year of study are you in?" is presented from a sample of 142 participants. The majority (88.03%) of participants are in their 1st year of study, with only a small number in their 2nd (2.82%), 3rd (5.63%), 4th (0.7%), or 5th (2.82%) year of study.

Furthermore, 3 open-ended questions were used, for which a qualitative analysis was applied. The results of the qualitative analysis are presented in the next three tables.

Table 4. Distribution of Responses on the Definition of Co-Creation

		N	%
How would you define co-creation?	Unsuccessful	1	0.7%
	I have no opinion	10	7.0%
	Moderate -Good	10	7.0%
	Interesting-Fun	22	15.5%
	Group-Creative	70	49.3%
	Necessary-Excellent	29	20.4%
	Total	142	100.0%

The Table 4 reveals the distribution of responses to the question "How would you define co-creation?" from a sample of 142 participants. The majority of participants (70, or 49.3%) described co-creation as "Group-Creative," indicating that they view co-creation as a collaborative process that involves the joint creation of new ideas, products, or services. 29 participants (20.4%) considered co-creation "Necessary-Excellent," indicating that they perceive it as a critical and outstanding approach. 22 (15.5%) found it "Interesting-Fun," and 10 (7%) considered it "Moderate-Good." Only 1 participant (0.7%) found it "Unsuccessful," while 10 (7%) did not have an opinion on the matter.

Table 5. Distribution of Responses on the Definition of Design Thinking Methodology.

		N	%
How would you define the Design Thinking methodology?	Difficult-Complex	10	7.0%
	No opinion	19	13.4%
	Good-Interesting	32	22.5%
	Organizational-Helpful	36	25.4%
	Very good-Creative	18	12.7%
	Effective-Flawless	27	19.0%
	Total	142	100.0%

Subsequently, the Table 5 represents the distribution of responses to the question "How would you define the Design Thinking methodology?" from a sample of 142 participants. Looking at the results, we can observe that the majority of respondents (54.2%) described Design Thinking as either "Good-Interesting" or "Very Good-Creative" or "Effective-Flawless". A significant number of respondents (25.4%) characterized it as "Organizational-Helpful". Around one-fifth of the participants (19.0%) perceived the methodology as "Effective-Flawless". Only a small percentage of respondents (7%) found Design Thinking to be "Difficult-Complex".

Therefore, the above table indicates that the majority of the participants had a positive perception of the Design Thinking methodology and viewed it as an effective and creative problem-solving approach.

Table 6. Distribution of Responses on the Usefulness of Problem-Solving in Real-Life Situations in a Course.

		N	%
Is it useful for you to solve real-life or job market problems in the context of a course? If yes, please explain your answer.	Not useful enough	2	3.1%
	Interesting	6	9.2%
	Friendly environment	1	1.5%
	The course is understandable	8	12.3%
	Students become more realistic	10	15.4%
	It provides experience and preparation for the future	38	58.5%
	Total	65	100%

According to the Table 6 the responses of a group of students to the question "Do you consider it useful to solve problems of the job market or real life in the context of a course? If yes, justify your answer" are presented. A total of 65 students participated in the survey.

Out of the total respondents, 58.5% (38 students) considered that solving real-life problems in the context of a course is useful because it offers experience and preparation for the future. Meanwhile, 15.4% (10 students) believed that it makes them more realistic, and 12.3% (8 students) thought that the course is understandable. Additionally, 9.2% (6 students) found it interesting, and 1.5% (1 student) found it to be a friendly environment. Finally, only 3.1% (2 students) did not find it useful enough. Therefore, the majority of the students agreed that solving real-life problems in

the context of a course is beneficial for their future, as it offers them practical experience and preparation for the job market.

Table 7 presents the descriptive statistics of questions R1-R25. Given that the average value of the questions has a maximum value of 5, from the questions related to the variable of co-creation, the questions R1 and R3 regarding students' satisfaction and the success of the co-creation approach gathered the highest average score of 4.2. The lowest average score of 2.8 was gathered by the question R4 which was related to the uncertainty and insecurity concerning knowledge and skills caused by the co-creation approach. The two questions R6 and R7 in design thinking about helping the project through methodology double-diamond and its use for the design of other projects received similar average scores of 3.6 and 3.7, respectively. Regarding the questions regarding the way groups function, the highest average score equal to 4.4. was noted by the question R11, about the distribution of roles and responsibilities between members of the group (which is the highest observed among all the close-ended questions of the questionnaire), where 81 students graded the question with the maximum possible score. The lowest average score and equal to 1.9 was recorded by the question R15 regarding addressing issues related to project ownership, where 79 students scored the lowest (this was also the lowest observed among all the close-ended questions of the questionnaire). In the questions related to skills, the highest average score of 4.2 was recorded by the question R22 regarding the organisation and achievement of goals. The lowest average score was scored by question R20 regarding leadership, i.e., the ability to assume the role of leader with respect for others, with an average score of 3.7.

Table 7. Descriptive Statistics of Questions Number R1-R25

Variables	Code	Mean	Std. Deviation
Co-Creation	R 1	4.2	.8
	R2	3.3	.8
	R3	4.2	.8
	R4	2.8	1.0
	R5	4.1	.9
Design Thinking	R6	3.6	.9
	R7	3.7	1.0
Teamwork	R8	4.3	.9
	R9	4.1	.9
	R10	4.3	.9
	R11	4.4	.8
	R12	4.2	.9
	R13	4.3	.9
	R14	3.3	1.3
	R15	1.9	1.2
	R16	3.6	1.0
	R17	4.1	.9
Skills	R18	4.1	.9
	R19	4.1	.9
	R20	3.7	1.0
	R21	4.0	.8
	R22	4.2	.8
	R23	4.0	.9
	R24	3.9	1.0
	R25	4.0	.9

Gender Identity

The variables that recorded co-creation, design thinking, teamwork and skills development were created versus gender identity from the sum of the student's responses to the questions of the individual sections to a five-point Likert scale. The measuring scale for co-creation ranges from 5 to 25, for design thinking from 2 to 10, for teamwork from 10 to 50, and for skills development from 8 to 40. Table 8 shows that there are no statistically significant differences in the variables of co- creation, design thinking, teamwork and skills development by the gender identity of the students, since $p > .05$ in all cases.

Table 8. T-test by the Gender Identity of the Students

Variables	Gender Identity	N	Mean	SD	t	df	Sig. (2-tailed)
Co-Creation	Women	50	19.3	2.3	1.093	140	.276
	Men	92	18.8	2.7			
Design Thinking	Women	50	7.4	1.5	.673	140	.502
	Men	92	7.2	1.8			
Teamwork	Women	50	40.5	6.6	- .297	140	.767
	Men	92	40.7	5.5			
Skills	Women	50	31.9	5.6	.171	140	.865
	Men	92	31.8	5.7			

Age

For the age distribution, it is observed that ages were mostly around 19 years old, except for observation 29, where one of the participants stated that he was 39 years old. This observation is marked with an asterisk because it is considered an extreme value and due to this, it deviates from the distribution by more than Q 3 + 3* IQR = 19+3*1=22. In this context, it is important to note that the outliers do not significantly affect the results. Table 9 shows that there are no statistically significant differences in the variables of co-creation, design thinking, teamwork and skills development by the age of the students, since $p > .05$ in all cases.

Table 9. F-test by the Age of the Students

Variables	Age	N	Mean	S. D.	F	Sig.
Co-Creation	18-20	124	19.0	2.5	1.091	.339
	21-22	14	18.4	2.8		
	>23	4	19.0	3.2		
	Total	142	19.0	2.5		
Design Thinking	18-20	124	7.3	1.7	.829	.439
	21-22	14	6.8	1.9		
	>23	4	6.8	1.5		
	Total	142	7.3	1.7		
Teamwork	18-20	124	40.6	6.0	.075	.928
	21-22	14	40.9	6.0		
	>23	4	41.0	4.8		
	Total	142	40.6	5.9		
Skills	18-20	124	32.0	5.8	1.148	.320
	21-22	14	29.6	4.6		
	>23	4	32.3	1.0		
	Total	142	31.8	5.6		

Year of Study

An analysis of variance (ANOVA) was conducted to examine the differences between the variables in relation to the students' year of study. Results showed that there were no statistically significant differences in co-creation, teamwork, and skills across the years of study ($p > .05$). However, a significant difference was found in design thinking ($p = .042 < .05$). Further Bonferroni's multiple comparisons evaluated up to the third year of study and found that there was no statistically significant difference in design thinking based on the year of study. Nonetheless, mean differences indicated that students in their first year of study scored higher in their responses compared to those in the other two years.

Previous Co-Creation Experiences

Table 10. T-test by Previous Co-Creation Experiences

Do you have previous experience in similar co-creation activities?	Yes/No	N	Mean	S. D.	t	df	Sig. (2-tailed)
Co-Creation	No	73	18.3	2.6	-3.226	140	.002
	Yes	69	19.7	2.3			
Design Thinking	No	73	6.8	1.7	-3.491	140	.001
	Yes	69	7.8	1.6			
Teamwork	No	73	39.3	6.0	-2.783	140	.006
	Yes	69	42.0	5.5			
Skills	No	73	30.6	5.9	-2.581	140	.011
	Yes	69	33.0	5.1			

The implementation of the t-test with p = .002< .05, found the existence of a statistically significant correlation between the co-creation variable and previous co-creation experiences, with a difference equal to 1.4. Students with co-creation experiences scored higher grades in the five questions regarding co-creation than those who stated the opposite. The t-test also revealed statistically significant correlations for design thinking, teamwork, and skills variables related to prior co-creation experiences. The results of the analyses are listed in the Table 10.

Teaching Method

The implementation of the t-test (Table 11) with p = .001< .05, also found a statistically significant correlation between the co-creation variable and the choice of teaching method (co-creation or traditional teaching), with this difference being in favour of people who chose co-creation equal to 2.1. Statistically significant correlations were also found for the effect of teaching method on teamwork and skills, with students who had traditional instruction selected achieving lower mean scores on teamwork and skills than those who had chosen co-creation. Importantly, no statistically significant relationship was found between design thinking versus the teaching method. The results of the analyses are listed in the Table 11.

Table 11. T-test by Type of Teaching

If you had to choose between co-creation and traditional teaching, what would you choose?	Type of Teaching	N	Mean	S. D.	t	df	Sig. (2-tailed)
Co-creation	Traditional teaching	19	17.2	3.7	-3.498	140	.001
	Co-creation	123	19.3	2.2			
Design Thinking	Traditional teaching	19	6.6	2.0	-1.886	140	.061
	Co-creation	123	7.4	1.7			
Teamwork	Traditional teaching	19	36.2	6.7	-3.658	140	< .001
	Co-creation	123	41.3	5.5			
Skills	Traditional teaching	19	28.2	7.3	-3.073	140	.003
	Co-creation	123	32.4	5.2			

Previous Co-Creation Experiences and Teaching Method

Students with previous co-creation experiences chose co-creation as a teaching method over traditional teaching at a percentage of 94.2%. The corresponding percentage for students with no previous co-creation experiences was 79.5%. In total, 123 students chose co-creation, compared to 19 students, who chose traditional instruction. Also, this difference appears to be statistically significant based on the X^2 test and the corresponding p of .010 (< .05).

Solve Real Problems Within a Course

Solving labour market or real-life problems within a course is useful for 56.8% of male students, with a corresponding rate for females at 43.2%. The students who did not find it useful were mostly men, with a participation rate of 80.9%, compared to a rate of 19.1% for women. Overall, negative responses were comparatively less frequent than positive ones, with a relative frequency of 47/142 and 95/142, respectively. Also, this difference appears to be statistically significant based on the X^2 test and the corresponding p of .005 (< .05).

Discussion

Students achieved satisfactory scores on each of the four variables, indicating satisfactory completion of the co-creation project. For the co-creation variable, the mean score for each of the questions ranged from 2.8 to 4.2; for the design thinking variable, from 3.6 to 3.7; 1.9 to 4.4 for teamwork; and 3.7 to 4.2 for skills (Table 7). Regarding standard deviation, representing the dispersion of values around central tendency measures, it can be supported that since the prices were low, most students expressed their unanimous attitude towards the issues under consideration without showing differences. In the variables of co-creation and teamwork, low scores of 2.8 (R4) and 1.9 (R15) (Table 7) are observed respectively. These scores are related to the degree of uncertainty and insecurity caused by the co-creation concerning students' knowledge and skills (R4) as well as any problems with the ownership of the co-creation project (R15). In these questions, the lower the average score, the higher the percentage of acceptance of the co-creation approach. Therefore, the integration of the approach is demonstrated in combination. It should be noted that according to Bergmark and Westman (2016), students are often unfamiliar with the process of co-creation, which can hinder understanding of new roles, cause uncertainty or insecurity about their knowledge and skills (Bovill et al., 2016), or lack of ownership of the work produced (Bovill et al., 2011; Carey, 2013; Martens et al., 2020). Teamwork scores implied satisfactory functioning of the co-creation groups with collective decisions, distribution of roles and responsibilities, and exchange of information, knowledge and experiences among team members. The effect of design thinking on teamwork, is confirmed according to the studies of Guaman-Quintanilla et al. (2022), Lake et al. (2021), and Panke (2019). Also, the implementation of design thinking in a collaborative learning environment such as co-creation, contributes to the cultivation of skills such as problem-solving and creativity, as it is found both from the satisfactory scores of the students and the conduct of previous research (Alhamdani, 2016; Balakrishnan, 2022; Lugmayr et al., 2014).

The results of the ANOVA test did not show any statistically significant differences in the variables of co-creation, design thinking, teamwork, and skills concerning gender identity, age, and the year of study of the students. This suggests that these demographic factors did not have a significant effect on the outcome variables. However, it is important to note that the absence of statistically significant differences does not necessarily mean that there are no differences between the groups being compared. It is possible that there are small or subtle differences that are not statistically significant due to sample size or other factors. Additionally, there may be other variables that were not measured or controlled for in the analysis that could have influenced the outcome variables. Further research may be needed to fully understand the factors that contribute to the differences or similarities in the outcome variables.

The students who had previous experiences in co-creation showed a higher score in terms of co-creation, design thinking, teamwork, and skills, according to the t-test (Table 10). Also, students who had chosen co-creation as the teaching method, compared to traditional teaching, scored higher in the variables of co-creation, teamwork, and skills, as demonstrated by the t-test (Table 11). An exception was design thinking, where no statistically significant relationship was found between design thinking and the teaching method.

The choice of co-creation by the students as a way of teaching their courses was independent of any previous experiences with co-creation activities, according to the X^2 test ($p = .010 < .05$). Also, the X^2 test showed that the students' opinion regarding the usefulness of solving problems in the labour market or real life in the context of a course concerning their gender identity is statistically significant since $p = .005 < .05$.

The understanding of the concept of co-creation was reflected in most cases through the terms "teamwork" or "team", as well as the terms "collaboration" and "group project," evaluating it as a beneficial practice, as a collective effort for some result, or the participatory action of members of a group to accomplish a common goal. The general conclusion that follows from the respondents' responses was a particularly positive message.

The design thinking methodology was defined as a method of solving problems multidimensionally, organised with a focus on teamwork, productive and absolute, helpful, complex. Also, expressed as a flowchart of problem-solving, creative, useful for understanding, and a method of solving problems initially externally to target the core of the problem.

In terms of utility in solving labour market or real-life problems in a course, students connected the problem-solving in the course to the real world, as they assessed how it prepared them for real -world market conditions. They also stated that it cultivates elements of professionalism and real awareness regarding the conditions they will be asked to face, while at the same time, they consider that the course acquires another interest and increases their degree of perceptiveness concerning it.

Conclusion

The results of the ANOVA test did not show any statistically significant differences in the variables of co-creation, design thinking, teamwork, and skills concerning gender identity, age, and the year of study of the students. The findings of this study underscore the pivotal role of co-creation and design thinking in enhancing students' skill development, particularly in the areas of empathy, communication, creativity, and problem-solving. The preference expressed by students for co-creation over traditional teaching methods further validates the efficacy of this approach

in fostering collaborative learning environments. The positive correlation observed between prior co-creation experience and higher appreciation of co-creation emphasizes the need for continued implementation of such approaches to learning.

Moreover, the study highlights the importance of active and collaborative learning environments in enhancing student engagement, team functioning, and skill development. The finding that increasing age appeared to inhibit co-creation, design thinking, team functioning, and skill development reinforces the need for sustained efforts towards fostering a culture of collaborative learning across all levels of education.

The study's results underscore the value of providing students with opportunities to acquire vital skills that will be relevant not just to their academic pursuits but also to their professional lives. By prioritizing active and collaborative learning methods, universities can equip their students with the necessary tools to excel in the ever-changing and competitive job market. It is essential to recognize the particular interest shown by first-year students in developing these skills, thus highlighting the need for early exposure to collaborative learning environments.

In conclusion, this study offers valuable insights into the benefits of co-creation and design thinking. Also, is emphasised the effectiveness of active and collaborative learning environments, and the need for sustained efforts towards fostering a culture of collaborative learning in higher education.

Theoretical and Practical Implications

Theoretical implications of this study suggest that co-creation and design thinking are critical in promoting students' skill development in the areas of empathy, communication, creativity, and problem-solving. The findings also suggest that co-creation is a more effective approach in fostering collaborative learning environments compared to traditional teaching methods. The study highlights the importance of promoting collaborative learning environments in universities to enhance student engagement, team functioning, and skill development.

The positive correlation between prior co-creation experience and higher appreciation of co-creation emphasizes the need for continued implementation of co-creation approaches to learning in higher education. This implies that universities need to encourage and provide more opportunities for students to engage in co-creation activities to enhance their learning experiences.

The practical implications of this study are significant for educators and policymakers. The study underscores the value of providing students with opportunities to acquire vital skills that will be relevant not just to their academic pursuits but also to their professional lives. By prioritizing active and collaborative learning methods, universities can equip their students with the necessary tools to excel in the ever-changing and competitive job market.

To achieve this, universities need to create a culture of collaboration that emphasizes the importance of working together towards common goals. This may involve developing policies that promote active and collaborative learning methods, providing resources to support co-creation activities, and encouraging faculty members to adopt co-creation approaches to teaching.

Furthermore, the study's results suggest that first-year students have a particular interest in developing collaborative skills. Therefore, universities need to provide opportunities for early exposure to collaborative learning environments, which will help them to acquire these skills from the beginning of their academic journey.

In conclusion, the theoretical and practical implications of this study suggest that co-creation and design thinking are critical in promoting students' skill development and enhancing collaborative learning environments. The findings highlight the importance of sustained efforts towards fostering a culture of collaborative learning in higher education, which will equip students with the necessary tools to succeed in their academic pursuits and professional lives.

Recommendations

Future research could include groups of students from different university departments and representatives from industry or business. It should be noted that the students' responses to this participation were also particularly satisfactory (Table 7, R16-R17). Also, after completing each of the four design phases of the double-diamond model, participants it would be useful to fill out a questionnaire in order to identify any possible gaps between the actual and expected results that should be achieved in each phase. Because this study comes from a course in the curriculum, it would be helpful to apply it to other courses in the curriculum to compare students' views on each of the concepts of co-creation, design thinking, teamwork, and cultivation skills. Finally, it would be beneficial to examine students' perceptions in various phases of their studies when they are given the opportunity to participate in collaborative learning environments through such approaches.

Limitations

One of the limitations of this research is the fact that the majority of participating students are in their first year of study. Therefore, their experiences of collaborative learning environments come mainly from their high school studies.

It should be noted that higher education operates under an entirely separate set of rules. Also, students' views on co-creation, design thinking, teamwork, and skill development come from recording student responses at one point, at the end of the co-creation approach. It would have been helpful if the opinions had been recorded at two different times (beginning and end of the process), so that possible changes in their opinions could also be recorded.

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Authorship Contribution Statement

Vardakosta: Concept and design, data acquisition, drafting manuscript, statistical analysis. Priniotakis: Critical revision of manuscript, final approval. Papoutsidakis: Critical revision of manuscript, final approval. Sigala: Critical revision of manuscript, final approval. Tsikritsis: Critical revision of manuscript, final approval. Nikolopoulos: Drafting manuscript, critical revision of manuscript, statistical analysis, supervision, technical support, final approval.

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Appendix

Table A1. Questions Number R1-R28 and Content

Variables	Code	Content
Co-Creation	R1	How satisfied were you with the co-creation approach?
	R2	How challenging were the tasks to complete your co-creation project?
	R3	Do you think your co-creation project was successful?
	R4	To what extent did your co-creation project make you feel uncertain or insecure about your knowledge and skills?
	R5	To what extent do you think the co-creation approach will be useful to you in your later life?
Design Thinking	R6	How much did the "double diamond" design thinking methodology help you in planning your project?
	R7	Would you use the "double diamond" design thinking methodology in your other projects?
Teamwork	R8	Was your work within the group a positive experience for you?
	R9	How did you communicate with your team members to design your co-creation project?
	R10	Were the collective decisions taken after an exchange of opinions between the group members?
	R11	Was there a distribution of roles and responsibilities among the team members?
	R12	Do you feel that your team has a collective understanding of the goals that should be achieved?
	R13	Was there sharing of information, knowledge, and experiences among your team members?
	R14	Was there criticism among your team members?
	R15	Have you encountered problems regarding the ownership of your project (Who owns it) among your team members?
	R16	If in your group there were fellow students from different departments of the university (Different specialties), do you think that the design of your project would be more interesting?
	R17	Do you think your project design would be more interesting if your team included representatives from industry or business?
Skills	R18	To what extent did you achieve the development of social skills? (Ability to communicate with other people, cooperation skills, etc.).
	R19	To what extent did you achieve interpersonal communication and empathy? (Ability to understand the other's position).
	R20	To what extent were you able to lead? (Ability to assume the role of leader with the respect of others).
	R21	To what extent did you achieve a strengthening of your problem-solving skills?
	R22	To what extent did you succeed in organising and achieving your goals? (Ability to set goals and work hard to achieve them).
	R23	To what extent did you achieve the development of your intellectual horizons? (Learning new things, improving knowledges and skills)
	R24	To what extent did you achieve a boost in your self-confidence?
	R25	To what extent did you develop your creativity? (Ability to think beyond the ordinary, think out of the box).
Multiple choice questions	R26	Have you had previous experiences in a co-creation activity? (Choice answer: Yes or no)
	R27	If you had to choose between co-creation and traditional teaching, what would you choose? (Choice answer: co-creation or traditional teaching)
	R28	Do you find it useful to solve labor market or real-life problems within a course? (Choice answer: Yes or no)