ORIGINAL ARTICLE

Multiplicity and diversity: the key for innovation

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ABSTRACT

This study explores the role of diversity in promoting learning innovation within educational teams. The focus is on the courses conducted under the ATTRACT Academy Umbrella; a co-innovation program funded by the European Commission's Horizon 2020 Program. The sample consists of three educational courses involving students from Esade Business School, Istituto Europeo di Design (IED), and Telecom and Computer Science Engineers students from UPC. The study uses qualitative and quantitative data from 88 students. Preliminary findings suggest that integration of diversity positively influences creative and innovative outcomes. Overall, we found that individual and disciplinary diversity positively influences creative and innovative team outcomes in educational courses. The study aims to contribute to the research on how diversity impact learning innovation. The limitations include the correlational nature of the analysis and the need for further generalization.

Keywords: Innovation; creativity; multiplicity; diversity; challenge based innovation; experience learning.

INTRODUCTION

Throughout history, innovation has been a driving force for human progress. This motivation stems from the novelty and practicality of innovative ideas (Castañer, 2016). Innovation addresses unresolved problems and necessitates learning and changing established habits. In contemporary Western culture, there is a notable emphasis on strategies that promote innovation. An example of such investment is the European Commission's "Horizon 2027" project, which allocates 95.5 billion euros to combat climate change, support the achievement s Sustainable Development Goals of the United Nations (UN), and enhance the competitiveness and growth of the European Union (EU) through innovative advancements in these areas (European Commission, 2023). Therefore, it is of central interest for next generations to learn how to innovate.

In a rapidly changing and complex world, where the emphasis on fostering learning innovation in higher education is ever-growing (Figueiredo et al., 2022; Lahdenperä et al., 2022), collaboration in teams among individuals with heterogeneous competences and profiles becomes central to learning innovation (Klein, 1996; Tuertscher et al., 2013). Much of the existing research in this field of team innovation has historically concentrated on investigating singular aspects of diversity as initial conditions for assessing innovation generation (e.g., Bantel & Jackson, 1989; Ancona & Caldwell, 1992; Ely, 2004; Auh & Menguc, 2005; Dahlin et al., 2005). For example, disciplinary diversity (Flinterman et al., 2001),

gender (Díaz-García, González-Moreno, & Jose Sáez-Martínez, 2013), and culture (Gassmann, 2001) have all been explored individually. However, the processes through which these various diversity factors influence learning innovation remain unexplored. Therefore, our research seeks to shed light into not only how diversity impacts learning innovation but also to uncover the moderating role of integration of diversity elements.

This study is particularly relevant because understanding the process of integration of diversity may impact educational experience and learning innovation (e.g., Charosky et al., 2018; Deo et al., 2020; Holzer et al., 2018). Our primary objective is to comprehend the influence of disciplinary diversity and multiplicity on learning innovation within higher education. Of equal importance is the investigation of the moderating role of the integration process of multiplicity and diversity. In the following paragraph we will briefly review the main concepts of the paper. Then we will examine the role of diversity in learning innovation of three educational courses which will lead us to derive conclusions.

THEORETICAL BACKGROUND

Learning innovation

Creativity refers to the ability to generate novel ideas (Castañer, 2016). Innovation is the capacity to generate new useful ideas (Castañer, 2016). We consider innovation as the final outcome of a process of ideas

generation (e.g., Amabile, 1983, 1988); in this way it is possible to differentiate creativity and innovation effectively avoiding ambiguity (Castañer, 2016).

The surge of interest in learning innovation has brought to the forefront a diverse range of methodologies and approaches aimed at fostering creative problem-solving (e.g., Brown, 2008; Jackson, 1991). Among these, Design Thinking has emerged as a prominent and versatile framework for learning and applying innovation principles (e.g., Calgren et al., 2014; Chang & Yen, 2021; Panke, 2019). Research by Liedtka and Ogilvie (2011) and Meinel et al. (2011) has highlighted the effectiveness of Design Thinking as a method to cultivate innovation competencies among learners. In our study we refer to learning innovation as the development of competences and skills to generate new and useful ideas (Hero & Lindfors, 2019; Ojasalo & Kaartti, 2021).

Innovation teams

At the basis of important innovation in human history there was a set of individuals that were collaborating and exchanging information to pursue the same goals: teams. Teams can be found in all sectors and on all hierarchical levels. Board of directors, football teams and academic committees are all examples of teams. Nowadays almost all institutions rely on teams as the reference point to cluster competences or solve problems.

A more structured definition establish that a team is composed by "two or more individuals who socially interact (face-to-face or, increasingly, virtually); possess one or more common goals; are brought together to perform organizationally relevant tasks; exhibit interdependences with respect to workflow, goals, and outcomes; have different roles and responsibilities; and are together embedded in an encompassing organizational system, with boundaries and linkages to the broader system context and task environment" (Kozlowski & Ilgen, 2006, p. 79). The focus of the study is mainly on teams with goals of learning innovation. The Research and Development (R&D) team represents the typical team with the primary goal to innovate. Most of the studies of team innovation are carried out considering R&D teams as the sample of the study (e.g., Shin & Zhou, 2007; Miron-Spektor et al, 2011).

The role of diversity

In the modern-day educational setting, diversity is no longer limited to cultural, ethnic, and gender variations alone. Disciplinary diversity represents a heterogeneous mix of individuals hailing from various academic fields, each contributing unique knowledge, methodologies, and problem-solving approaches (Klaassen, 2018). Embracing this diversity can lead to appreciating the challenge of working in diverse teams, where ideas converge, clash, and intertwine to spark innovation and drive transformative change (Bailey et al., 2021). Diversity is not enough if there is no integration of knowledge. Students need to recognize and reconcile their differences in backgrounds and disciplines (Bailey et al., 2021). Therefore, interpersonal skills are key in disciplinary diverse teams to integrate differences (Figueiredo et al., 2022).

The term "multiplicity" has found varied usage across academic contexts, typically spanning from mathematics and philosophy to sociology and psychology. In each of these fields, "multiplicity" takes on a distinct meaning and significance, reflecting its versatility as a concept that can be adapted to address diverse questions and issues. In an effort to enhance clarity and precision, we adopt an approach inspired by the work of Bouncken, Brem, & Kraus (2016) and Shliakhovchuk (2019). We propose that multiplicity refers to the multitude of perspectives that arise from individuals' differences (e.g., academic, gender, age) coming together in a new education setting. These varied viewpoints can result in a cross-fertilization of ideas, facilitating the exchange of best practices, and encouraging interdisciplinary collaboration. By welcoming the input of individuals from different fields, universities can unlock novel ways of thinking and problem-solving that may not have been conceivable within a more homogenous environment.

Amidst the diverse tapestry of disciplinary backgrounds, the integration of multiplicity plays a crucial moderating role in unlocking the full potential of learning innovation (García-Rodríguez et al., 2012). Integration refers to the process of leveraging differences as a source of new knowledge and insights (Eppinger & Kressy, 2002). When teams prioritize inclusive and collaborative learning environments, they can foster meaningful interactions among students and scholars, encouraging the synthesis of diverse perspectives to tackle complex challenges.

METHODS AND DATA

Our study focuses on the courses conducted under the ATTRACT Academy Umbrella EU project, a co-innovation program seeking to act as a bridge between two communities – research and industry – strengthening mutual trust funded by the European Commission (EC)'s Horizon 2020 Program, cooperation, and interdisciplinary blending among the later stages of the innovation cycle.

The sample of the study consists of 3 educational courses based on the Challenge Based Innovation methodology (Papageorgiou et al., 2021; G. Charosky et al., 2018; Hassi et al., 2016), a challenge driven education experience using a design thinking and systems thinking approach to solve societal challenges applying cutting edge technologies to develop holistic and sustainable long-term solutions.

For this research we used the data from 3 batches: Challenge Based Innovation 2022 (CBI-FP) with 27 students, Challenge Based Innovation for Artificial Intelligence 2023 (CBI4AI) with 34 students, Technology

for Social Innovation 2023 (TeSi) with 27 students. From these courses, 24 (27%) students come from Esade Business School, 27 (30%) students from the Istituto Europeo di Design (IED) and 36 (43%) Telecom and Computer Science Engineers students from the UPC coming also from different countries having 40 different nationalities in total. Students explore challenges framed under the SDG framework, identifying societal challenges to solve using early-stage development cutting edge technologies from the ATTRACT program developing social innovative and impactful solutions. These courses involve also the participation of the Experiential Learning Innovation team from IdeaSquare at CERN.

The learnings and insights come from all the different sources of data that we synthesized, categorized and coded in a joined database. In Table 1, we described the different sources of data and its relationship with the findings.

of disciplinary diversity. Further, 78% of the participants felt they were able to work productively with people from different disciplinary backgrounds.

The main qualitative arguments that support the awareness of diversity were valuing diversity as a source of soft-skills development: "*The main learnings and inputs have been firstly to work in a group with people from totally different fields*" (CBI4AI 2023 Interaction Design, IED). Also, other contributions pointed diversity as a source of learning experience for future career development: "*I will know how to handle the design process of a product and how to work with all kinds of people. [...] The most I value is the new perspectives of thinking this course gave me and teamwork collaboration.*" (TeSi 2023 Telecom Engineer Degree, UPC*)*.

Table 1. Data description.

Source of data	Description	Type of data	Yield to final result
Final feedback session	Guided open discussion at the end of the course about what they have experienced, suggestions for improvements and team dynamics reflection.	Recorded, transcribed and coded group discussion.Qualitative data	Diversity awareness Self-assessment on learned skills. Diversity impact
Final learning reflection feedback form	Self-assessment evaluation of student learnings, reflections and comments regarding the course and its impact in the future, diving in learning goals achievement, skills acquired and future prospects. Questionnaire details available in the annexes	Written responses from the students, Likert scales and coded open questions Quantitative & qualitative data	Diversity awareness Self-assessment on learned skills. Diversity & multiplicity impact
Student projects grades	Grades from the student projects regarding their final idea presentation, final report and project prototype Grading rubric available in the annexes	Student projects grades according to the course Quantitative data	Diversity & multiplicity impact
Student diversity information	Age, gender, previous studies, current discipline, and professional experience.	Students' data base Quantitative data	Diversity & multiplicity impact

We have analysed frequencies, percentages, and correlations between the student's final reflection form on self-perception of learning goals achievements, the diversity indicators and the grades of the projects. The text from the reflection form was inductively analysed with open coding (Charmaz, 2006). Then the codes were categorised thematically (Braun & Clarke, 2006) based on perception of collaborations. To bring more light into the findings we have completed them with the insights coming from transcribed and coded open discussion sessions and open questions from the final reflection form.

RESULTS

Are participants aware of diversity?

The findings of this research in multidisciplinary show that 94% of the participants were aware of the diversity present in the teams. 82% acknowledged the significance

What are the most valuable skills in working in diverse teams?

Participants reported that the most valuable skills and competences acquired in working in R&D teams are dealing with a multidisciplinary environment (78%) and the ability to collaborate effectively within teams (72%). both from the quantitative and qualitative sources. For example, 80% of participants gave a score >5 (scale from 1-7) on multidisciplinary environment and 76% of participants did the same for ability to work in teams.

The main valuable skills pointed out are related to people interactions, "it shows how it is to work all together with passion in a long-term project with a great multidisciplinary team and makes people grow in a lot of ways. But the best thing was the people, thank you all for doing this experience one of a kind that most of us will never forget." (CBI 2022 Physics Engineering UPC student). As well as empathy as a key element to innovate and focus on the end user: "I think the most important skill

I got through this course is patience and empathy" (CBI 2022 Telecom Engineering Degree UPC), in addition to: "Being open to taking information from other backgrounds, combining all kinds of professions with design, and being more empathetic will all add more value to my career." (CBI4AI, Interaction Design, IED).

Does diversity predict learning innovation?

The preliminary exploratory analysis shows a positive relationship, although not significant, between team diversity with creative and innovative results measured by their project grades (cor = .24, t = .93, p = .23). Teams with higher degree of diversity (at least 3 different disciplines, more than 3 nationalities and larger age gap using Simpson's Diversity Index) performed better. For example, team 1 from CBI4AI with 6 members from 4 disciplines, 4 nationalities, ages between 22 and 44 years old, balanced gender distribution and a grade of 9,8 out of 10. Team 4 from TeSi with 4 people from 4 different disciplines, 3 nationalities, ages between 21 and 34, with one woman obtained a grade of 9.8.

From a qualitative analysis, it is clear how students recognize the impact of diversity on learning innovation. Diversity in a broad sense not only knowledge and expertise but background and life experience are key for innovation and student's future careers: "Working with a multidisciplinary and diverse team in terms of age/professional experience/nationality really got me engaged in honing my leadership." (CBI 2022 MBA Esade). More examples of that from a qualitative point of view are the following reflections such as: "This will help me when working with interdisciplinary teams a lot. Also, it has helped me see how to think for innovative solutions given a real situation with some constraints […] while

having always in mind the final user and the impact we wanted to make." (CBI-FP Telecom Engineering Degree UPC student) pointing out the importance of understanding people to create useful solutions to problems. It's from the ideas discussions and exchanges that good and meaningful ideas come through: "I think working with people with totally different background and discussing ideas is a beneficial experience […] Explaining my mindset and how the ideas can work is also challenging, as others may not understand how things work in my sector easily" (CBI4AI Masters in Business Analytics, Esade).

Moderating role of integrating multiplicity

Finally, the moderation role of integrating multiplicity is observed when all individuals recognized the integration of different knowledge and perspectives, they scored higher in innovation. Integration of diversity is pointed as crucial for generation of innovation and their future career: "In my future professional career I won't be working with people from the same school and degree, thus, it's important to be part of a team with people from different fields, cultures, points of view... Overall it's really enriching being part of it." (CBI4AI Computer Science Masters UPC student) and "I think that working with designers and business students helped me to improve my communication skills and to empathize more with the purpose of the product." (CBI4AI, Computer Science Masters UPC student). Students that mentioned the importance of integration of multiplicity obtained higher than average team and individual grades.
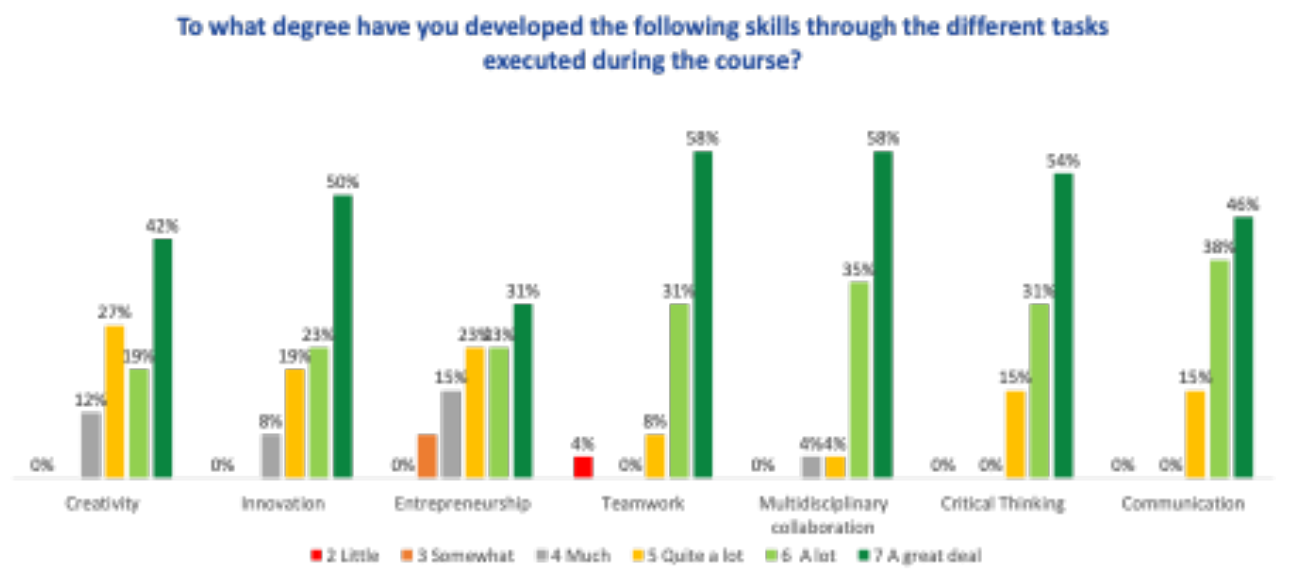
Fig. 1. Data from the Final learning reflection feedback form of CBI-FP 2022, CBI4AI & TeSi 2023

DISCUSSION AND CONCLUSIONS

The study represents a starting point for developing a holistic understanding of R&D teams' processes. Indeed, it provides valuable insights on consequences of multiplicity. For example, we identified the process of integrating multiplicity into the team dynamics as beneficial to generate innovative outcomes. Students find important to learn how to deal with diverse individuals not only for the purposes of learning innovation but also for their future careers. In the feedback, it is recurrent the presence of integration of different knowledge as key element to successfully learning innovation. The results complement the findings from Feng & Björklund (2022) and Ojasalo & Kaartti (2021) for which multidisciplinary innovative teams is a key ingredient to reach team goals and develop soft skills (e.g., time management and interpersonal skills). In our study we show how the integration of multiplicity is important to achieve team goals and learning innovation.

The study has a significant importance in the literature on the processes that induce diverse teams to enhance learning innovation. It supports the stream of literature that recognizes the process determinant in heterogeneous functional teams (e.g., Paulus & Yang, 2000; Sethi et al., 2001; Auh & Menguc, 2005; Somech, 2006; Cabrales et al, 2008; Chowhan, 2016). However, the study has several limitations that prevent the conclusions from being generalized. This analysis is correlational, so it does not allow to infer causality. For example, there could be non-measured confounding variables that determine outcomes (e.g. personality). Furthermore, the limited sample size impedes the attainment of adequate statistical power, hindering the derivation of meaningful conclusions from the quantitative analysis.

Further to improve the measurements of the learnings and its key determinant factors, future research should explore self-efficacy creativity and innovation tests and measurements to be implemented before and after the courses. In this way, we can compare the results and assess if there has been a quantifiable improvement in their innovation capabilities due to going through the course experience. For the future analysis we are working on developing a multiplicity index including our broader conception of diversity, not only background but age, nationality, and gender too, and test for correlations with the level of innovation and quality of the projects, as already the preliminary analysis are suggesting.

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ANNEX

Final feedback reflection form questionnaire

Form page 6/9

7. **Values & attributes**
To what degree did you put the following <u>values & attributes</u> into practice through the different tasks developed in the course? *

	Not at all	Little	Somewhat	Much	Quite a lot	A lot	A Great Deal
Empathy (seeing the world through others' eyes; understanding others' realities and needs)	○	○	○	○	○	○	○
Responsibility (recognizing the broader effects of one's actions - or inactions - and striving for creating change that has positive impacts on society and the environment)	○	○	○	○	○	○	○
Grit (having the energy, passion and courage to persevere and follow-through a task or goal despite failures or disappointments along the way)	○	○	○	○	○	○	○

8. **To what degree 1 (not at all) to 7 (a great deal) do you feel you made the most out of the opportunities to develop these values & attributes?** *

1	2	3	4	5	6	7

9. **What are the 3 take aways you achieved by the end of the course?** *

Form page 8/9

12. **Please explain your contribution to the project and provide some examples (what are you brininging, getting, your role, expectations, etc.)** *

13. **Do you think you are going to develop more your CBI4AI project?** *
- ○ Yes
- ○ No
- ○ Maybe

14. **In case of yes or maybe, please explain your plans and your potential role (alone or with others) in this future developments.**

15. **How do you think the skills learned and experiences achieved in this course will help you on your future professional career?** *

16. **How likely are you to recommend this course to your friends? 1 (not at all) to 7 (a great deal)** *

1	2	3	4	5	6	7

17. **Please share any comments on how we could improve the structure, organization and course content.**

18. **Please add any additional insights, feedback or comments you'd like to share regarding the course and your learning experience.**

Form page 7/9

10. **Please choose 3 adjectives to describe your learning experience in this course.** *
Seleccioneu com a màxim 3 opcions.
- ☐ Challenging
- ☐ Intense
- ☐ Unique
- ☐ Stressful
- ☐ Risky
- ☐ Rewarding
- ☐ Fulfilling
- ☐ Enjoyable
- ☐ Enriching
- ☐ Personal Growth
- ☐ Unexpected
- ☐ Wide
- ☐ Interactive
- ☐ Lost
- ☐ Grity
- ☐ Positive
- ☐ Creative
- ☐ Dilated
- ☐ Predictable
- ☐ Teamwork spirit
- ☐ Tough
- ☐ Tolerance
- ☐ Other: Please describe

11. **Please on a scale from 1 (not at all) to 7 (a great deal) value your role and contribution to the project and final outcomes of your team** *

1	2	3	4	5	6	7

Form page 9/9

See you soon!

Many thanks for your great participation and contribution, we hope you had an enriching and amazing learning experience. This is not a goodbye, you are now part from the CBI4AI alumni family!

Student projects evaluation form

TEAM GRADE (evaluating the presentation, prototype and project report)	1. Understanding the challenge: Desk research and insights from desk the interviews conducted are well described. Tools learned in the first half of course that capture the learning process are included.
	2. Finding a solution: Problem is well redefined and focused. Process of ideation using the tools learned during the second part of the course is provided. Different ideas explored are described, as well as how convergence happened.
	3.The final idea/solution: Final idea and prototype using sketches, technical drawings, and photographs of models of study and final prototypes are presented. The following questions are addressed: What is the idea, how it does it work, and how does it solve the problem? Why is it idea great? What is the expected impact?
	4.Depending on your disciplinary expertise, please evaluate the following distinct aspects of the idea: 1) Design elements; 2) Business proposition; or 3) Technical specifications
	5. Final presentation: Visual and oral elements, structure, and effectiveness of the delivery.
	6.Prototype expo, including video: Demonstration of the idea, poster presentation, physical prototype design and delivery.
	7. Coaching sessions: Team participation and preparation; ability and willingness to reflect and
	8. Checkpoint presentations
	Overall Team Grade 55% (average of the above)
Individual grade	Attendance & Participation 10%
	Individual mark (coaches, according to teamwork performance) 10%
	Peer Assessment 15%
	Final discipline-specific deliverables 10%
	Final Individual Grade (55% Team Grade + 45% Individual grades)