Student interest in technology transfer with educational technologies in the "Fabrication Lab" for entrepreneurship

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Business education, Entrepreneurship, Fabrication laboratory, Technology transfer

Abstract

The main objective of the study was to determine the level of interest in entrepreneurship in academic innovation, considering the variables of interest, education, social norms, and entrepreneurship. The research methodology corresponds to a non-experimental design; a digital questionnaire was given to a sample for the study, consisting of 400 students from a private university in Arequipa, Peru. It used reliability and validity tests, factor analysis, and the modeling of structural equations using partial least squares. There were two well-defined phases, firstly, an exploratory factor analysis was carried out, this analysis aimed to condense the information in original variables into smaller series, secondly, a confirmatory factor analysis was carried out, using structural equation modeling based on variances. It is concluded that the proposed structural model, is explained from its variance by 72.5% (determination coefficient) and the factorial load that it exerts on the dependent variable such as university entrepreneurship, is significant and determining.

Introduction

In the current era, the student interest in technology transfer and the use of educational technologies is experiencing an exponential growth. The students of today are digital natives, and their enthusiasm for technology has become a powerful engine for innovation and creativity. Pinheiro, Moraes & Fischer, argue that it has become essential to prepare young people for a global economy that is increasingly driven by technology and digital manufacturing. In this context, it is relevant to explore how educational technologies and makerspaces can play a critical role in promoting entrepreneurship and the application of student ideas. Tolpygo et al. hold that technology transfer refers to the process of sharing and applying knowledge and technologies developed in an academic or business environment to industry and society as a whole. This transfer is essential to convert research and innovation into practical and marketable solutions. In a world where the pace of technological change is dizzying, students are increasingly motivated by the idea of contributing to society and the labor market through technology transfer and entrepreneurship.

Manufacturing labs, often called Fab Labs, are interdisciplinary learning spaces equipped with advanced tools and technologies that allow students to design, prototype, and manufacture physical products. These environments provide an exceptional platform for students to turn their ideas into reality, fostering creativity and entrepreneurial spirit. When combined with educational technologies, such as virtual reality, artificial intelligence, and online learning, manufacturing labs become places where students can acquire practical skills and apply their knowledge in a tangible way.

Entrepreneurship will be valued more in the future due to the need to constantly adapt to new technologies and the ability to take advantage of them to create innovative and sustainable businesses. Entrepreneurs who embrace technology can have a significant impact on the economy and society, making this skill highly desired in the future business world (Sampene et al. 2022).

Kim et al. maintain that in an increasingly innovation- and automation-driven world, the role of digital manufacturing is becoming a fundamental pillar in diverse industries and economic sectors. First, it offers greater efficiency and flexibility in production, enabling the customization and rapid adaptation of products to changing market demands. This leads to a reduction in costs and production times, resulting in a significant competitive advantage for organizations that can leverage this technology as explained by Hilkevics & Hilkevics (2017). Additionally, it is constantly evolving, fueled by technological advances in areas such as artificial intelligence, 3D printing, robotics, and the Internet of Things. The interconnection of these elements through information technology promotes greater automation and the creation of more agile and efficient supply chains.

This paper not only focuses on promoting entrepreneurship in a fabrication laboratory, but it also analyzes the educational theories and models that underlie technology transfer and digital fabrication within academic settings. Recognizing the importance of a strong theoretical foundation, we explore how pedagogical concepts and learning models, such as constructivism, active learning, and project-based learning, intersect with technology transfer and digital fabrication. This holistic approach not only seeks to provide a comprehensive view, but it also seeks to inspire educators, students, and administrators to rethink and strengthen their educational practices in a world driven by technological innovation.

Literature review

Entrepreneurship in the digital manufacturing laboratory

Digital fabrication labs are closely linked to entrepreneurship. These spaces are known as "maker spaces" and here manufacturing processes converge with the aim of solving problems in society (Curioso et al. 2020). Kalyaev, Salimon & Korsunsky (2020) analyzed the power of how digital manufacturing technologies, developed in universities, did not stop even during the pandemic; and even better, they managed to become professional businesses thanks to technology transfer once the pandemic was over.

Contreras-Barraza et al. 2022in their study of the perspectives on entrepreneurship in the manufacturing lab, they note that more than 70% learn better how to manufacture, without prior knowledge, in groups that are interested in a common project. In other words, it is better when the lab provides them with projects and manuals so that they themselves can develop and apply the known project. According to Porfírio et al. 2022, Entrepreneurship should be a pillar in higher education. He emphasizes that the social atmosphere should have a positive impact on the interest in carrying out a project, this supported by hackathons and ideathons that are linked to interdisciplinary laboratories that promote application in society, government, and universities.

Development of novel-engineering-based maker education instructional model

Equitable education is a sustainable development goal. However, there is a gap in education between urban and rural students, as well as a gap in access to information and communication technologies. To address these gaps, a sustainable maker education model is needed that is suitable for rural school students. Therefore, it is important to combine novel engineering, maker education, and design thinking to create an instructional model for a novel engineering-based maker education (Kim, Seo & Kim 2022)

Fig 1. The Research Procedure of NE-Maker Instructional Model Development (Kim et al. 2022)

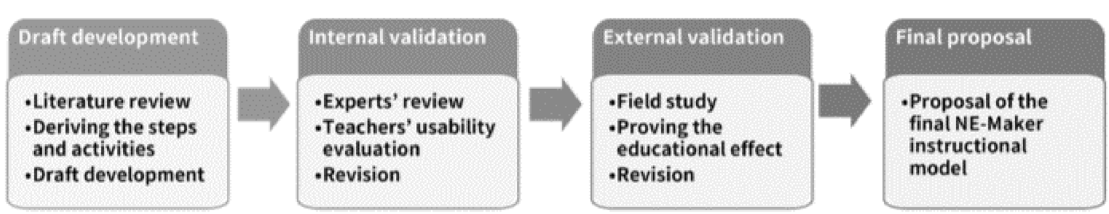


Figure 1 shows the three phases of the development of a novel engineering-based maker education (NE-Maker) model. The first phase is the development of the model, which includes a literature review, the derivation of steps and activities, and the drafting of a draft. The second phase is the evaluation of the model, which includes an expert review and a usability evaluation. The third phase is the final proposal of the model, which includes the modification and improvement of the draft based on the recommendations derived from the validation process.

In the first phase, the model is developed through a literature review on maker education, novel engineering, and design thinking. This review is used to identify key principles and practices that can be incorporated into the model. Then, the steps and activities of the model are derived from this review. Finally, the draft of the model is drafted. In the second phase, the model is evaluated to ensure that it is effective and appropriate for rural school students. The expert review is used to obtain feedback on the content and structure of the model. Usability evaluation is used to collect feedback on the ease of use of the model. In the third phase, the model is modified and improved based on the recommendations derived from the validation process. Then, the final model is proposed (Li & Zhan 2022).

This educational model has the potential to help close the education gap between urban and rural students. The model is sustainable, as it uses low-cost teaching tools. In addition, it is suitable for rural school students, as it is based on their interests and skills.

(Zheng et al. 2023) in their study "Knowledge-based engineering approach to defining robotic manufacturing system architectures" analyzed that robotic manufacturing systems have proven to be an effective solution for modern manufacturing companies to cope with increasing customer demands and market competition. However, these systems may not be able to fully satisfy user requirements due to the difference between user and design perspectives. Therefore, designing robotic manufacturing systems requires iterative processes that significantly increase development costs and delivery time.

Fig 2. Relationship of Novel Engineering, Maker Education, and Design Thinking (Kim et al. 2022)

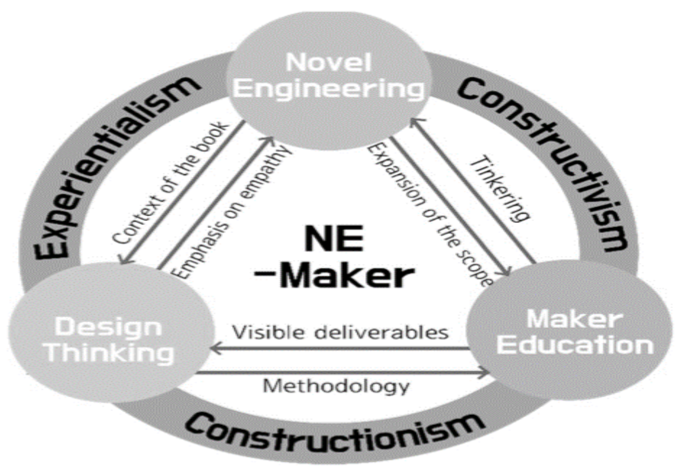


Figure 2 shows a Venn diagram that represents the different forms of engineering. The outer circle represents traditional engineering, which focuses on the design and construction of systems and products. The inner circle represents novel engineering, which is a new approach to engineering that combines engineering education methods and literacy with maker education. The middle circle represents maker engineering, which is a student-centered approach that allows students to learn about engineering through the creation of practical projects (Xu et al. 2023).

The diagram shows that novel engineering is a subset of traditional engineering, but it also overlaps with maker engineering. This is because novel engineering is based on the principles of traditional engineering, but it also incorporates elements of maker education, such as project-based learning and a student-centered approach. The diagram also shows that maker engineering is a subset of traditional engineering, but it also overlaps with novel engineering. This is because maker engineering is based on the principles of traditional engineering, but it also incorporates elements of novel engineering, such as a focus on problem-solving and creative thinking (Tabarés & Boni 2023).

Fig 3. Draft of the NE-Maker Instructional Model (Kim et al. 2022)

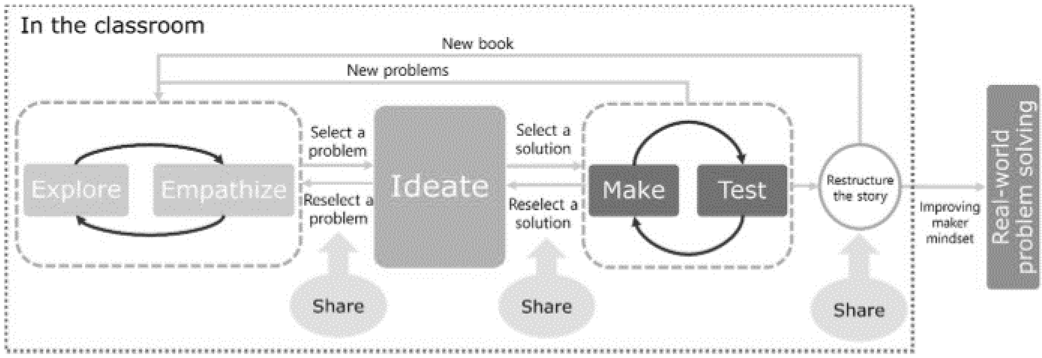


Figure 3 shows a flowchart that represents the novel engineering-based problem-solving process. The process consists of five steps (Tabarés & Boni 2023).

-Problem identification: The first step is to identify the problem that needs to be solved. This can be done through observation, research, or collaboration with users.
-Problem analysis: Once the problem has been identified, it must be analyzed to understand its causes and consequences. This can be done through data collection, identification of key factors, and model development.
-Problem-solving strategy: In this step, a strategy is developed to solve the problem. This may include idea generation, evaluation of alternatives, and selection of a solution.
-Solution implementation: The solution is implemented in the real world. This may require prototype development, solution testing, and scale implementation.
-Solution evaluation: Once the solution has been implemented, it must be evaluated to determine its effectiveness. This can be done through data collection, result analysis, and user feedback.

Technology and Entrepreneurship

Based on Zahra, Liu & Si (2023) digitalization has driven the creation of new business models. Emerging companies, such as technology-based ones, often arise from the combination of advanced technology and an entrepreneurial mindset. FabLabs prepare students to embrace this disruptive approach. Martínez-Martínez; Shah, Sukmana & Fianto (2022) maintain that technology fosters innovation, and innovation is essential for business competitiveness. FabLabs are a breeding ground for innovation, which in turn contributes to the success of businesses driven by former student entrepreneurs.

Practical Education vs. Theoretical

The Experientialism theory, proposed by Dewey and landed in a manufacturing laboratory by Arenas 2023) emphasizes the importance of experience in the learning process. This theory advocates for practical learning as an effective means of acquiring skills and knowledge. FabLabs align with this perspective by providing an environment where students can apply their theoretical knowledge to real projects. Constructivism Ghazi & Matansh (2023) suggests that students build their knowledge through active interaction with their environment. FabLabs, by providing access to manufacturing tools and technology, foster active learning and the creation of solutions to real-world problems. This promotes critical thinking and problem-solving, essential skills for entrepreneurship. Based on the above considerations, the following hypotheses are proposed:

H1. There is a significant relationship between Attitude towards entrepreneurship and Entrepreneurial Intentions Tech Transfer

H2. There is a significant relationship between Perceived Entrepreneurial Capability and Entrepreneurial Intentions Tech Transfer

H3. There is a significant relationship between Business Education and Entrepreneurial Intentions Tech Transfer

H4. There is a significant relationship between Perceived Social Norms and Entrepreneurial Intentions Tech Transfer

Research Methodology

The research was carried out with a sample of 400 undergraduate students from the Catholic

University of Santa Maria and Continental University in Arequipa, Peru, whose ages ranged from 18 to 24 years, being men (44.5%) and women (55.9%) with a standard deviation of 2,152. The sample was chosen randomly, and the questionnaire was used from May to August 2023 and sent digitally.

The questionnaire is an adaptation that was carried out in the research: "Measuring the intention of university entrepreneurs using structural equations" (Saucedo 2018). The instrument employs a 5-point scale, similar to the Likert scale, with 1 indicating complete disagreement and 5 indicating complete agreement. With a preliminary study sample of 50 students to determine reliability levels, the instrument was validated and approved for research, yielding the following results: Cronbach's alpha α = 0.877 and McDonald's coefficient ω =0.942 which are considered as good (Gliem & Gliem 2003). The Kaiser-Meyer-Olkin (KMO) test was used to measure how well the items in the study fit together into their corresponding factors. The KMO score was 0.869, which is considered to be excellent (Stephanie Glen 2016) (Kaiser 1958).

This means that the items in the study are well-suited for factor analysis, which is a statistical technique used to identify underlying factors that explain the relationships between variables. The software IBM SPSS Statistics (v. 27), Smart PLS (v. 4.0) were used to perform the statistical calculations.

Findings/results

For the factor analysis, the variables were codified like this: Attitude towards entrepreneurship (AHE); Perceived Entrepreneurial Capability (CEP); Business Education (EP); Entrepreneurial Intentions Tech Transfer (IEE); Perceived Social Norms (NSP). SmartPLS software was used to calculate the external loads using the Partial Least Squares (PLS) algorithm, which is a regression algorithm that uses weight vectors. The following adjustments were made: the maximum number of iterations was set to 300 and the stopping criterion was set to 10^-7. Table 1 shows the matrix of external loads with their respective values, using items with acceptance coefficients greater than or equal to 0.700 as the cutoff criteria.

Table 1. External loads sampling adequacy – SMART PLS

	AHE	CEP	EP	IEE	NSP
AHE2	0.878				
AHE3	0.906				
AHE4	0.931				
AHE5	0.867				
CEP2		0.748			
CEP3		0.868			
CEP4		0.775			
EP1			0.828		
EP2			0.824		
EP3			0.825		
EP4			0.822		
IEE1				0.783	
IEE2				0.805	
IEE3				0.911	
IEE4				0.810	
IEE5				0.822	
IEE6				0.893	
NSP2					1.000
NSP3					0.706

The reliability and construct validity are expressed in Cronbach's alpha, the results are between 0.706 and 0.931, which is acceptable. The composite reliability coefficient (rho_A) (Saidi & Siew 2019) is used to assess the dependability of the results obtained in the development and design of partial least squares (PLS) (da Rosa Possebon et al. 2018) models. To demonstrate composite reliability, the values of rho_A should be greater than 0.7. The results in this study vary between 0.850 and 0.927. Therefore, the composite reliability criterion is applied, with an acceptance criterion of rho_A > 0.7. This ensures that reasonable levels of reliability and internal consistency are demonstrated for each of the variables. The values of rho_A under this criterion range between 0.850 and 0.927. The values of the average variance extracted (AVE) (Bacon, Sauer & Young 1995) range between 0.680 and 0.878. These results exceed the recommended minimum value of 0.500, indicating that convergent validity is acceptable in the model components (dos Santos & Cirillo 2023).

The results of this study demonstrate that the PLS model is reliable and valid. The composite reliability and average variance extracted values are all above the recommended thresholds. This means that the model can be used to measure the constructs of interest with confidence, as seen in Table 2.

Table 2. Constructs of reliability and validity

	Alpha Conbrach	Rho_A	Rho_C	AVE (Average Variance extracted)
Attitude towards entrepreneurship (AHE)	0.918	0.927	0.942	0.878
Perceived Entrepreneurial Capability (CEP)	0.852	0.850	0.810	0.691
Business Education (EP)	0.843	0.878	0.895	0.680
Entrepreneurial Intentions Tech Transfer (IEE)	0.915	0.918	0.934	0.704
Perceived Social Norms (NSP)	0.839	18.509	0.803	0.683

The Fornell and Lacker (Hilkenmeier et al. 2020) proposal, determinates a test for discriminant validity was performed by comparing the square root of AVE for each variable to the correlations between the variables. The results showed that the square root of AVE was greater than the correlations for all variables, indicating that the discriminant validity of the model is well established. (See Table 3).

Table 3. Discriminant validity, Fornell Larcker Criterion

	AHE	CEP	EP	IEE	NSP
AHE	**0.896**				
CEP	0.541	**0.769**			
EP	0.712	0.596	**0.825**		
IEE	0.744	0.591	0.814	**0.839**	
NSP	0.063	0.068	0.182	0.145	**0.827**

Table 4 shows that the discriminant validity is positive, which proves that the constructs are correctly separated. In other words, the constructs that should be separated by interpretative logic are indeed separated. using the Heterotrait-Monotrait relationship (HTMT). The HTMT coefficient was used in this way because of the results, which are valid because their values are below the 0.85 conservative cutoff point suggested by **Rönkkö & Cho**.

Table 4. Discriminant validity, Heterotrait-monotrait ratio

	AHE	CEP	EP	IEE	NSP
AHE					
CEP	0.670				
EP	0.804	0.777			
IEE	0.805	0.748	0.804		
NSP	0.103	0.187	0.193	0.163	

Table 5 shows the results of a bootstrapping test. This test works by creating 10,000 new samples from the original data, with each sample containing some duplicates of data points. The model parameters are then estimated for each of the new samples. The standard deviation of the estimated parameters is then used to calculate the standard error of the estimate (Vrigazova 2021). Based on the results of the bootstrapping test, hypotheses H1 and H4 are accepted, while hypotheses H2 and H3 are rejected. This is because the p-value for hypotheses H2 and H3 is less than 0.05, which is the significance level.

Table 5. Bootstrapping

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T statistics (|O / STDEV|)	P Values
AHE→IEE	0.311	0.299	0.128	2.435	**0.015**
CEP→IEE	0.108	0.154	0.112	0.960	0.337
EP→IEE	0.524	0.481	0.136	3.860	**0.000**
NSP→IEE	0.021	-0.002	0.110	0.190	0.850

Figure 4 is a graphical representation of R2 (coefficient of determination) using Partial Least Squares Structural Equation Modeling (PLS-SEM), which explains that Perceived Social Norms (NSP) -> Entrepreneurial Intentions TECH Transfer (IEE): Perceived Social Norms has a positive relationship with entrepreneurial intentions. For each unit that Perceived Social Norms increases, entrepreneurial intentions averages 0.146 units. It is statistically significant ($p<0.001$), which means that it is highly likely that this relationship is not going to change. Attitude towards entrepreneurship (AHE) -> Entrepreneurial Intentions TECH Transfer (IEE): Attitude has a positive and very significant relationship with Entrepreneurial Intentions.

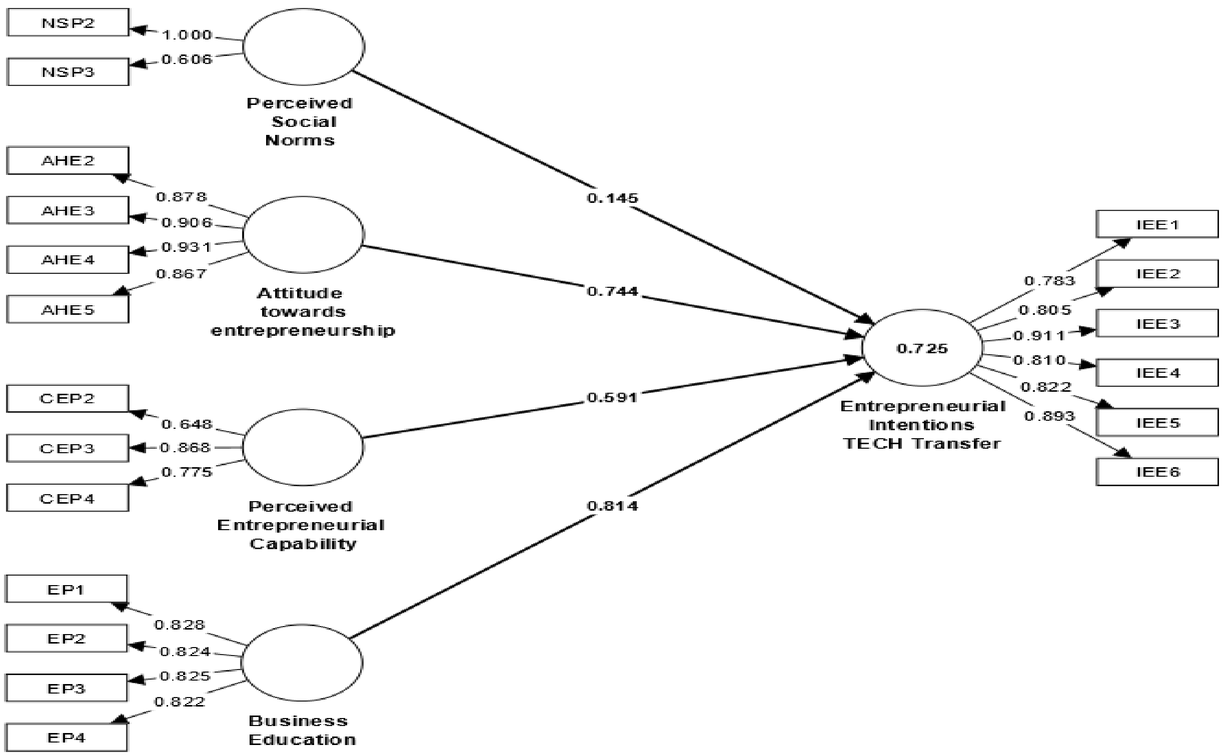
For every unit that Attitude towards entrepreneurship increases, Entrepreneurial Intentions increases by an average of 0.744 units. This relationship is statistically significant, indicating that there is a moderate probability that this relationship exists and is not due to chance.

The Perceived Entrepreneurial Capability (CEP) -> Entrepreneurial Intentions TECH Transfer (IEE): perceived entrepreneurial capability has a positive and significant relationship with Entrepreneurial Intentions, for every unit that Perceived entrepreneurial capability increases, entrepreneurial intentions averages 0.591 units. It is statistically significant ($p<0.001$), which means that it is highly likely that this relationship is not going to change.

Business Education (EP) -> Entrepreneurial Intentions TECH Transfer (IEE): business education has a positive and significant relationship with Entrepreneurial Intentions, for every unit that business education increases, entrepreneurial intentions average 0.814 units.

The R^2 of 0.725 suggest that 72% of the variability in the Entrepreneurial Intentions TECH Transfer (IEE) can be explained by the variables "Perceived social norms" (NSP), "Attitude towards entrepreneurship" (AHE), "Perceived entrepreneurial capability" (CEP) and "business education" (EP). Therefore, it is inferred that there are other factors not included in the model that are also influencing.

Fig 4. Coefficient of determination R^2 – PLS- SEM



Limitations and direction for future research

FabLabs play a fundamental role in promoting entrepreneurship in higher education. Through hands-on education, the fostering of creativity and technology, they prepare students to face the challenges of the business world. Some of the world's most innovative companies have originated in FabLabs, which reinforces the importance of these spaces in the global entrepreneurial ecosystem. In a constantly changing world, the relationship between FabLabs and entrepreneurship in higher education is an essential component for forming future entrepreneurs and innovative leaders.

Fig 5. Guidelines to prioritize ventures with national impact

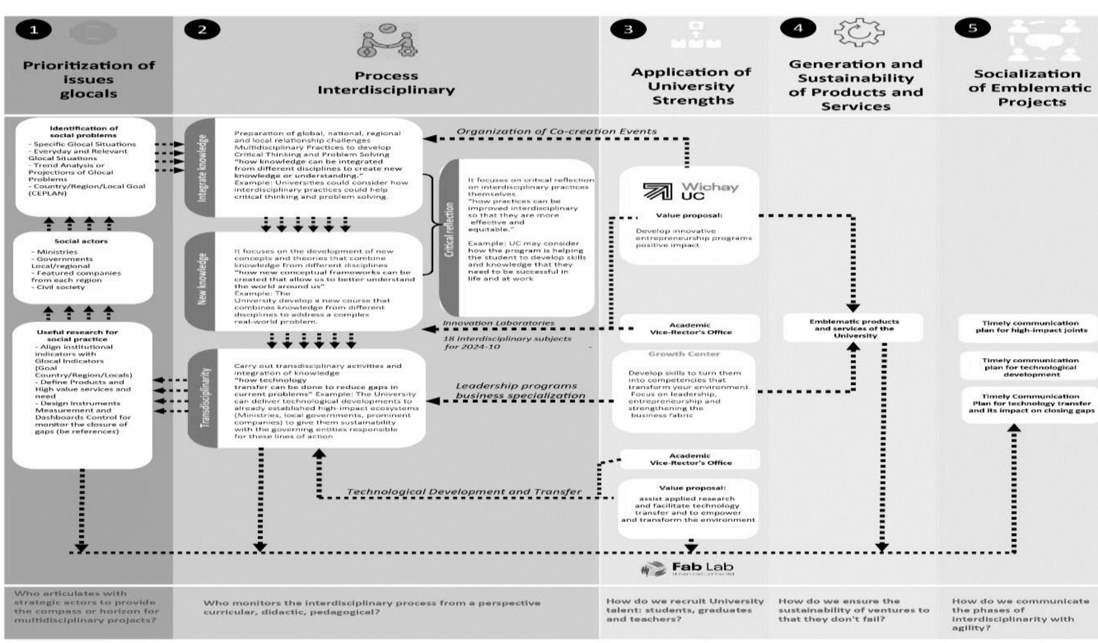


Figure 5 is a prioritization plan for Glocal activities (considering the national plans made by the government for each region, city, and locality). These activities must involve academic and/or administrative areas for the benefit of interdisciplinary entrepreneurship projects by the faculties in the university, supported by business accelerators, scientific production, manufacturing laboratories, and business training centers.

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