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TECHNOLOGICAL SKILLS, SELF-EFFICACY, AND RESILIENCE WITH SEM MODEL AS PREDICTORS OF INVESTIGATIVE SKILLS IN ECUADORIAN HIGHER-LEVEL STUDENTS

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Abstract

Research skills are essential for academic and professional training in higher education; however, their development faces significant challenges, especially in contexts such as Ecuador, where few studies analyze the factors that shape them. The objective of the study was to determine the extent to which technological competencies, academic self-efficacy, and resilience predict research competencies among Ecuadorian higher education students. The methodology applied was an empirical, cross-sectional, correlational, explanatory research with a non-experimental design. The analysis was implemented using the structural equation model (SEM). 517 students from two higher education institutions in Ecuador participated. Four validated instruments were administered: the Digital Competence Questionnaire for Future Teachers (CCDFM), the Perceived Self-Efficacy Scale Specific to Academic Situations (EAPESA), the Brief Resilience Scale (CD-RISC-10), and the Perceived Research Competencies Scale (RPCs). Data were analyzed using SEM, with adjustments evaluated using CFI, RMSEA, and SRMR. Results: The SEM model showed an adequate fit (CFI = 0.901; RMSEA = 0.079 and SRMR = 0.376). Technological competencies ($\beta = 0.51$, $p < 0.001$) and resilience ($\beta = 0.16$, $p < 0.001$) were significant predictors of research competencies, while academic self-efficacy did not show a significant direct relationship ($p = 0.157$). The correlations showed positive associations among all variables ($r = 0.48$–0.66, $p < 0.001$). It is concluded that integrating technological competencies and resilience strategies into university programs strengthens research skills.

Keywords – Research skills, Higher education, Technological skills, Self-efficacy, Resilience.

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1. Introduction

Most countries worldwide are currently promoting research as a fundamental pillar of their educational policies (Barbachán-Ruales et al., 2021; Gonzalez-Brambila, 2021; Nolazco-Labajos et al., 2022). The United Nations Educational, Scientific, and Cultural Organization (UNESCO) has maintained that the

mission of the research is also to contribute to achieving the Sustainable Development Goals (SDGs), so that higher education institutions are currently implementing these skills gradually to produce new knowledge and respond to the most pressing needs of society (UNESCO, 2021).

The university is the entity that enables the development of research skills in students, strengthening the graduate profile that produces information, rather than merely acquiring knowledge (Martínez & Castellanos, 2018; Martínez-Mora et al., 2018). However, many studies indicate that higher education students lack research training, hindering the creation of new knowledge and its application in real situations (Colás-Bravo & Hernández-de-la-Rosa, 2021; Díaz-Espinoza & Cardoza-Sernaqué, 2021; Iovu & Bărbuță, 2022).

Training in research skills in Ecuador is hindered by the scarcity of studies evaluating the factors that strengthen these skills. (Vance-Chalcraft et al., 2022). Therefore, students trained in higher education institutions must be competent, with diverse competencies encompassing values and attitudes (Argelagós et al., 2022; Tastanbekova et al., 2021), particularly research-related skills (Senisum et al., 2022).

Research skills are understood as a set of methodological skills and attitudes at the cognitive level that enable students to improve their training and develop the competence to generate new knowledge (Guamán et al., 2020; Jeréz et al., 2022). Research competencies include critical thinking, problem-solving, teamwork, and an ethical disposition in research (Moreira-Moreira et al., 2021; Sánchez-Trujillo & Rodríguez-Flores, 2023). We must consider that we promote the development of those skills from the earliest years of the training process (Duche-Pérez et al., 2023; Hernández-Navarro et al., 2019).

One basic aspect related to how research skills can be acquired is the use of technologies in higher education for this purpose. The introduction of technological skills into university education allows students to learn in a more meaningful way and at a higher level, even beyond their research capacity (Cabero-Almenara & Roig-Vila, 2019; Candia-López, 2023; Riveros-Anccasi et al., 2022). In the same way, academic self-efficacy can appear as a facilitating aspect of the attitude that all those students who go through the research path have, and thus be a variable that appears related to the performance that students can have on this question to investigate (Ames et al., 2023; Santa-Cruz et al., 2024).

In parallel, academic resilience appears as a psychological mechanism that favors academic success and facilitates research competence, since it is associated with the specific efforts that students may have to overcome discomfort and adversity; this, together with the fact that adapting to complex environments successfully, supposes, generically, the adaptation to the development of oneself (Meneghel et al., 2021; Saldarriaga-Ccoricasa et al., 2022 y Vargas-Guzmán & García-Alejo, 2021).

Although the importance of skills in Ecuador is recognized, serious difficulties arise in their development. Higher education institutions have limited research training in terms of resources, insufficient training strategies, and scarce studies on the factors that determine the development of competencies (Senisum et al., 2022; Tastanbekova et al., 2021).

As a consequence of this problem, it is necessary to carry out a study that addresses technological competencies, academic self-efficacy, and resilience in the development of research training in Ecuadorian upper-level students as competencies that allow them to face academic demands and contribute to their own area of knowledge in the advancement of science (Monzón-Pinglo et al., 2023).

The importance of the study lies in the need to support educational and training strategies in higher education institutions to enhance students' research skills. Once the factors that affect the development of these skills are identified, they will be enhanced through the design of the most effective strategies to increase scientific production and learning in Ecuadorian higher education.

The main objective of this study is to determine the extent to which technological competencies, academic self-efficacy, and resilience predict research competencies among Ecuadorian higher education

students. To this end, a structural equation model (SEM) is proposed to yield more precise and relevant results (Kline, 2023).

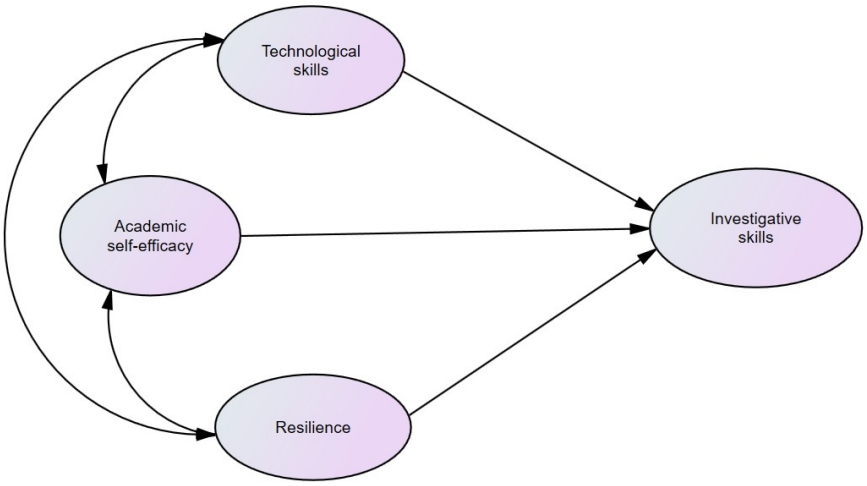

Figure 1. SEM model

Based on the above, the following hypothesis is proposed:

Technological competencies, academic self-efficacy, and resilience are predictors of research competencies among Ecuadorian higher education students.

2. Methodology

2.1. Methodological Design

The study was framed as an empirical, cross-sectional, correlational, explanatory research design, as proposed by Ato et al. (2013). The analysis was conducted using structural equations modeling (SEM), a methodology that enables the evaluation of complex interactions among the variables under investigation (Kline, 2023). The research aimed to address a knowledge gap regarding the relationships among technological competencies, academic self-efficacy, and resilience, and to examine how these factors, using the SEM model, predict investigative competencies among Ecuadorian higher-level students.

2.2. Participants

517 students enrolled in 2025 in two higher education institutions in Ecuador participated in the research. The sample was selected using non-probabilistic convenience sampling (Hernández-Sampieri & Mendoza, 2018). With a base of 43 observable variables, 4 latent variables, and an anticipated effect size of 0.20, a desired probability of 0.05 with a statistical power level of 0.8, the recommended minimum sample size is 342 cases; thus, a sample of 517 participants was considered, of which 417 belonged to the Tsáchila Higher Technological Institute and 100 to the Adventist Higher Technological Institute of Ecuador, that is, a sample greater than the minimum recommended by a calculator Soper (2021) that defines the sample size for the SEM model as evidenced in Table 1.

Parameters	Values
Expected effect size	0.2
Desired statistical power level	0.8
Number of latent variables	4
Number of variables observed	43
Probability level	0.05
Minimum sample size to detect the effect	342
Minimum sample size for the model structure	2,041
Minimum recommended sample size	2,041

Table 1. Calculation of Soper SEM Sample

Inclusion criteria

- Students of higher level equal to or over 18 years of age.
- Students of a higher level of both sexes.
- Students of higher levels residing in Ecuador.
- Students of higher levels who are enrolled in the year 2025.

Exclusion criteria

- Students of higher level under 18 years of age.
- Students of higher levels who do not reside in Ecuador.

2.3. Data Collection Instruments

The data collection method was an online survey. The instruments used are detailed below:

a) The Perceived Research Competencies Scale (PRCS) was developed and validated by Merino-Soto et al. (2022) in a Peruvian population. Its purpose is to evaluate university students' perceptions of competencies in research activities. It is one-dimensional, consists of 4 items, and uses a Likert-type response format with 7 response options ranging from "not at all true" to "very true". It demonstrated evidence of (a) content validity through item analysis, (b) internal structure with Mokken scale analysis and modeling of structural equations to examine the item-construct relationship, the differential functioning of the items, and the alpha reliability of Cronbach and Omega > 0.90, and (c) association with external factors.

b) The Digital Competence Questionnaire for Future Teachers (CCDFM) was developed and validated by Cabero-Almenara et al. (2020) in a Spanish sample. Its objective is to evaluate the perception of personal strengths and areas for improvement in the use of digital technologies. The questionnaire consists of 20 items distributed across five dimensions: technological literacy (4 items), communication and collaboration (3 items), information search and processing (4 items), digital citizenship (3 items), and creativity and innovation (6 items). The response scale is Likert-type, with levels of commitment to digital technologies ranging from 0 (minimum) to 10 (maximum). In terms of reliability, the instrument obtained a Cronbach's alpha coefficient of 0.931.

c) The Perceived Self-Efficacy Scale Specific to Academic Situations (EAPESA) was created by Palenzuela (1983) and validated in an Ecuadorian context by Regatto-Bonifaz et al. (2023). Its purpose is to identify academic self-efficacy among students at various levels of higher education. It has a one-dimensional structure with 9 items and a Likert-type response scale, with four options ranging from never (1) to always (4). The higher the score obtained, the greater the academic self-efficacy. The instrument has an internal consistency reliability level of $\omega = .91$ [.90 - .93].

d) The Connor-Davidson Brief Resilience Scale (CD-RISC-10), developed by Connor and Davidson (2003) in the United States and adapted by Bernaola-Ugarte et al. (2022) for a Peruvian context, is

designed to measure resilience in university students. Likewise, it consists of 10 items, is one-dimensional, and uses a 5-point Likert-type scale to rate responses, ranging from none (0) to a lot (3). Its validity and reliability have been established through confirmatory factor analysis, which yielded optimal fit indices and explained 47% of the total variance. In addition, the instrument's internal consistency has been confirmed using Cronbach's alpha and McDonald's Omega, both with a value of .827.

2.4. Procedure

First, the ethics committee of the graduate school of the Universidad Peruana Unión approved No. 2024-CE-EPG-00077. Then, informative letters were issued to the highest authority of the higher education institutions where the research was applied to request the respective authorization; subsequently, with the entities that agreed to apply the study, meetings were held with the career and research coordinators to explain the objective, characteristics, and scope of the research. The information collection instruments were administered online via a Google Form. The first section of the form included instructions, the study objective, and informed consent, highlighting that participation was voluntary and anonymous. Subsequently, the data were cleaned and coded.

2.5. Data Analysis

To better understand the characteristics of the variables analyzed, a descriptive analysis was conducted. This included identifying measures of central tendency and variability, maximum and minimum values, confidence intervals, and indices of kurtosis and asymmetry for the overall sample. Subsequently, a correlation analysis was conducted among all the latent and observable variables to assess the strength of the relationships. In the final stage, to represent the interaction between endogenous variables (technological skills, academic self-efficacy, resilience) and exogenous variables (research skills), a structural equation model (SEM) was used to examine their relationships.

The hypothesis was analyzed using maximum likelihood estimation, given the ordinal nature of the variables (Flora & Curran, 2004). The suitability assessment of the proposed model fit was performed using several indicators: the comparative fit index (CFI), the non-normalized fit index (NNFI) or TLI, the root mean square approximation error (RMSEA), the residual standardized root mean square (SRMR), the incremental fit index (IFI), and the parsimony-normed fit index (PNFI). The JAMOVI and AMOS SPSS software were used for data analysis.

3. Results

3.1. Descriptive Statistics

Table 2 provides a detailed overview of descriptive statistics for Investigative competencies, technological competencies, academic self-efficacy, and resilience among 517 respondents. It is highlighted that technological competencies have the highest average value (81.7) and the largest range (20-120). In contrast, self-efficacy shows lower dispersion, with a standard deviation of 5.94. All the statistics indicate a trend towards high values, suggesting a distribution with an extended left tail. The distributions are also flat, indicating that the data are not strongly concentrated around the mean. Regarding reliability, Cronbach's alpha is high at 0.94, indicating strong internal consistency for the scales.

Descriptive	Investigative Competences	Technological Competences	Academic self-efficacy	Resilience
N	517	517	517	517
Mean	18.7	81.7	26.9	38.5
Medium	20	89	27	40
Standard deviation	7.39	26.1	5.94	8.40
Minimum	4	20	9	10
Maximum	28	120	36	50
Skewness	-0.454	-0.543	-0.338	-0.685
Kurtosis	-1.08	-0.695	-0.282	0.177
Cronbach's alpha (α)	0.980	0.983	0.949	0.951

Table 2. Descriptive statistics of the variables

3.2. Correlations for the Study Variables

Table 3 presents a matrix of correlations among investigative, technological, academic self-efficacy, and resilience competencies, all of which show positive and meaningful relationships. It is worth emphasizing the strong correlation between academic self-efficacy and resilience, with a value of 0.660, indicating that those who trust themselves are more resilient. The notable correlation between investigative and technological skills is also explored, with a value of 0.642, indicating that the development of investigative skills is linked to the use of technology. Academic self-efficacy is also correlated with the development of research skills (0.480) and technological skills (0.601). Similarly, the correlation between Investigative Competencies and Resilience (0.504).

Variables	TCI	TCT	TAF	TRE
Investigative skills (TCI)	1			
Technological skills (TCT)	0.642 ***	1		
Academic Self-efficacy (AS)	0.480 ***	0.601 ***	1	
Resilience (TRE)	0.504 ***	0.588 ***	0.660 ***	1

Note. * p < .05, ** p < .01, *** p < .001

Table 3. Correlation matrix for the study variables

3.3. Structural Equation Model.

Figure 2 shows the structural equation model (SEM), involving four latent variables: academic self-efficacy, resilience, technological skills, and investigative skills. The latent variables are supported by indicators observable by factor loadings between 0.71 and 0.97. This technique shows that academic self-efficacy positively increases resilience (0.67) and technological competencies (0.60); likewise, technological competencies influence research (0.51). In addition, resilience has a positive relationship with research (0.16), underscoring that greater resilience can lead to greater research action. The model shows good fit indices (Browne & Cudeck, 1992), CFI = 0.901; TLI = 0.900, RMSEA = 0.079; SRMR=0.376; IFI = 0.901; PNFI = 0.901.

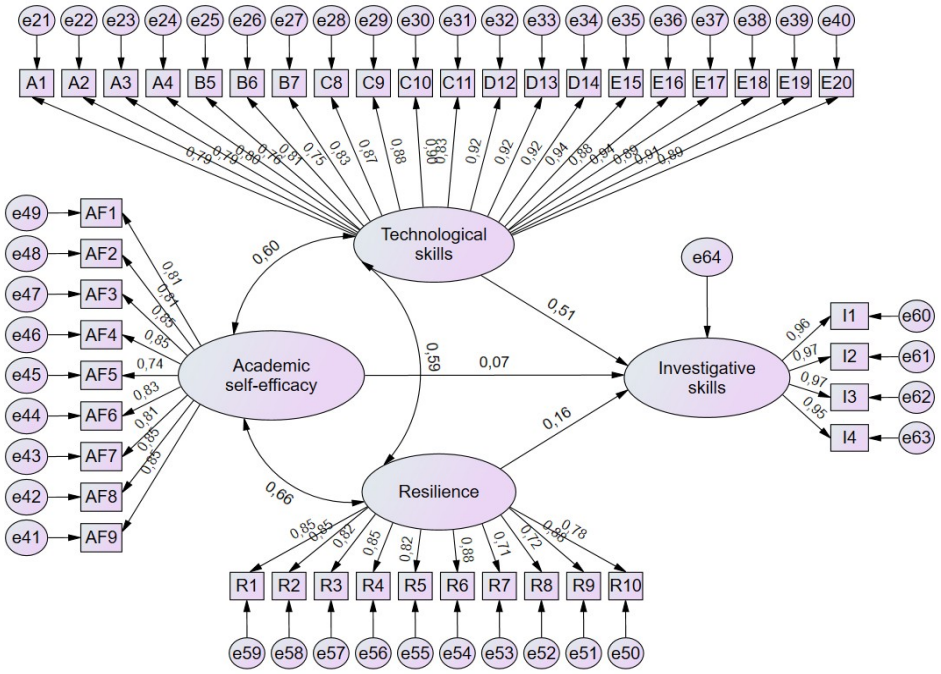

Figure 2. SEM model for research competencies

Table 4 presents a detailed analysis of the relationships among the SEM model's variables, including investigative, technological, academic self-efficacy, and resilience. It presents the β coefficients, standard errors, z-statistics, and p-values that allow these relationships to be verified. In this sense, research capacities are strongly associated with both technological skills and resilience, as both are statistically significant ($p < 0.01$). In contrast, we find no significant association between research capacities and academic self-efficacy ($p = 0.157$).

Variables		Standardized Beta	I.C.		B	Z	p-value
C.Inves	Technological	0.790	0.6397	0.941	0.5051	10.30	< .001
C.Inves	Self-efficacy	0.214	-0.0826	0.510	0.0718	1.41	0.157
C.Inves	Resilience	0.365	0.1394	0.590	0.1590	3.17	0.002

Table 4. Coefficients, standard errors, and confidence intervals

4. Discussion

The study aimed to determine the extent to which technological competencies, academic self-efficacy, and resilience predict research competencies among Ecuadorian higher education students, using a structural equation modeling (SEM) approach. The findings partially validate the hypothesis and provide important insights into the interaction between personal and contextual variables in the development of research competence in Ecuadorian higher education. In this sense, Arzuaga-Ramírez et al. (2023) show that research skills are on the rise, with the main contributions in health, education, and engineering in Latin America.

Among the findings, the most robust was the significant effect of technological competencies on research competencies ($\beta = 0.51$, $p < 0.001$), which corroborates the role of digital literacy in training researchers in 21st-century higher education. Within this framework, efficient access to sources of scientific information, static and bibliographic tools, and the ability to communicate findings through digital platforms are one of the axes of the research process in current academic practice (Cabero-Almenara & Roig-Vila, 2019; Candia-López, 2023).

Previous research in Latin America indicated that the technological gap conditioned the development of research (Gonzalez-Brambila, 2021), but this study quantitatively establishes this relationship in the Ecuadorian environment. Along the same lines, the research he conducted with students at a university in Peru showed a substantial positive, compensatory relationship between these skills (Riveros-Anccasi et al., 2022). This finding has interesting practical implications and higher education institutions have to include in their curricula, compulsory subjects or modules focused on the development of digital competencies applied to research; skills in the management of statistical information programs (RStudio, SPSS), bibliographic managers (Zotero, Mendeley), and academic publishing platforms, as they recommend Cabero-Almenara et al. (2020).

Another result of considerable importance was the significant relationship between academic resilience and research competencies ($\beta = 0.16$, $p < 0.01$). This finding was very similar to other research that characterizes resilience as a central psychological competence for overcoming uncertainty, failure, and the pressure of the research process (Meneghel et al., 2021; Monzón-Pinglo et al., 2023). In the study that identified items assessing the ability to overcome failures and adapt to circumstances, these items showed a positive correlation with research skills, confirming that perseverance and emotional stability play a role in the continuity and closure of academic projects.

Unlike other research that tends to relate resilience to emotional well-being (Vargas-Guzmán, & García-Alejo, 2021), this research shows that resilience can affect academic research performance. The sample's contextual approach can explain this difference, as it consists of students from technological institutions in a context where daily life challenges require supervision. From an educational practice perspective, these results suggest the possibility of implementing organizational strategies to promote resilience through orientation and tutoring programs, psychological counseling, and training in coping strategies and time management, among others.

Although the literature review and experience with academic self-efficacy suggest a relationship with research competencies, this study did not find a significant direct relationship ($p = 0.157$). The positive correlations with resilience ($r = 0.66$) and with technological competencies ($r = 0.60$), however, point to a more indirect or mediated eventual impact, as they point out Ames et al. (2023), to the extent that it could be justified that students with the highest perception of academic self-efficacy are those who feel more capable of taking on challenges, which leads them to help explore more technological tools and persevere in the face of difficulties, which does not necessarily translate into these investigative competencies immediately.

Another possible explanation lies in participants' mostly undergraduate level of education. In these initial stages, students may not have yet internalized the relationship between personal trust and research performance. Previous studies conducted at the postgraduate level, where academic demands are greater, and research autonomy is key, have shown this relationship (Regatto-Bonifaz et al., 2023), as have findings in undergraduate students, where an association between both variables has been observed (Santa-Cruz et al., 2024).

Consequently, it is suggested that academic self-efficacy development should be a progressive process, supported from the first training cycles through the implementation of significant research experiences, positive feedback, and collaborative learning activities (Barceló-Hidalgo et al., 2022). These experiences help us build a solid academic self-concept that supports the transition to more complex levels of investigative thinking (Corona-Meza, 2023).

Although the theoretical model of the present study is based on widely consolidated literature, its contribution lies in the empirical and contextual advances over previous research conducted in Latin America. Unlike previous studies that have addressed these variables in isolation or through simple descriptive or correlational analyses (Gonzalez-Brambila, 2021; Riveros-Anccasi et al., 2022), this work integrates technological competencies, academic self-efficacy, and resilience into a structural equation model (SEM), allowing us to examine direct and indirect effects on research competencies simultaneously. Likewise, the study provides specific evidence in the Ecuadorian context, where empirical research on

psychoeducational predictors of research competence in higher education is limited, thereby contributing to the regional validation of more complex explanatory models.

While the study has met the overall objective and provided important evidence, it has certain limitations worth considering. First, the analysis has been carried out with a sample of students from two Ecuadorian institutions, limiting the results to other educational realities. Extending the sample to include public and private universities across different regions of the country will allow the proposed model to be validated and enriched.

Second, a cross-sectional design imposes a limitation on establishing cause-and-effect relationships. A longitudinal design could facilitate the observation of the evolution of those competencies over time and more appropriately capture the differential effects of each predictor variable. It should also be considered for future research, including, for example, contextual variables such as institutional support, real access to bibliographic resources, or academic motivation, which are of great importance in the evolution of research competencies.

Finally, analyzing mediation or moderation models could help better understand the interactions among academic self-efficacy, resilience, and technological competencies, to design more targeted, as well as more effective, interventions across different educational contexts.

5. Conclusions

It is concluded that technological competencies and resilience are significant predictors of research competencies among Ecuadorian higher education students. Likewise, self-esteem, although it did not play an influential role in research skills, is positively related to other study variables and serves as a mediating factor in the development of these competencies. The structural equation model (SEM) presented adequate global fit indices, indicating that the proposed model has adequate explanatory and predictive capacity for the development of research skills.

The study leads to reflection on the need for comprehensive academic training that allows the harmonious development of all students' faculties, especially those related to research, and on the implementation of research skills and resilience actions in study programs to foster a more productive and technologically competent academic culture. The structural equation model (SEM) should be replicated across other educational contexts, training levels, and socio-cultural realities to contrast the stability and validity of the relationships.

Declaration of Conflicting Interests

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Authors' contributions

Jenrry Fredy Chávez-Arizala: conceptualization, formal analysis, research, project management, supervision, visualization, writing—preparation of the original draft.

Juan Jesús Soria-Quijaite: data processing, acquisition of funds, methodology, software, validation, writing—review and editing.

Data availability

Data available upon request

Use of Artificial Intelligence

The authors declare that the content of the article has not been developed using Artificial Intelligence. They specify the purposes for which it has been used

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