

Technological Ecosystem in Innovation Management in Peruvian Schools

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Abstract

The objective of the research is to determine the influence of the technological ecosystem in the management of innovation in schools in Peru, where the type of research is basic, with a quantitative approach, explanatory level, with a non-experimental design. The sample is 148 workers of schools in mining camps in southern Peru. It is concluded that there is an influence of the technological ecosystem in the management of innovation, given the value of $p = 0.000$ and Nagelkerke's Pseudo- $R^2 = 60.50\%$. The results demonstrate the relevance of the technological ecosystem as a source to improve innovation management, given the insertion of technologies, digitalization, and information systems for the facilitation of innovation and decision-making.

Keywords: *Technological ecosystem, innovation management, digital ecosystem.*

INTRODUCTION

Innovation management is crucial to create new products and processes, as well as to improve the benefit for the user of the innovation (Baumann et al., 2016), therefore, an innovation is not limited to new products/processes/procedures, but improvements that add, open or improve new approaches. Nitjarunkul (2015) states that it is important to determine the understanding of the concepts by those involved in agreement with Stål & Babri (2020), which indicates that it is necessary to investigate the internal and external factors that affect the actors involved in the learning process, considering to know the opportunities and threats that affected at the time of being able to apply the information and communication technologies, that is, to know the Technological Ecosystem. Manea (2015) states that the management of innovation in regular basic education for the present research in the schools of mining camps in southern Peru, is a key element in the realization of the quality educational process, serves as socio-cultural, economic, and democratic values and principles, referring that beyond fundamental should be mandatory, it is considered to be one of the essential vectors that explain whether a country is poor or rich.

Advances in technology in education, as well as in other areas, have been enhanced by innovations as technological and independent artifacts that quickly become obsolete or

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simply abandoned (Aguilar-Forero & Cifuentes, 2020). The same situation has occurred in Peruvian schools, where the scarce pedagogical innovations, despite investments in technology, lead to the conclusion that the gap between technology and educational innovation must be closed in order to understand why this situation has not been resolved, and why the same mistakes are still being made, i.e. acquiring equipment without knowing the technological ecosystem of the institution or sector (Albornoz-Barriga, 2019).

A clear example is the investment made in some Peruvian schools on behalf of mining camps, for the acquisition of interactive whiteboards that were not used for many years and that with the arrival of smart projectors have been replaced. The purchase of robotics material is also observed, in charge of the area of science and technology as in most schools, however, the technological ecosystem of the teachers of the area is not adequate to develop robotics. As a result, state-of-the-art robotics material is obtained, which then falls into disuse and is on the way to obsolescence. Innovation management is affected and stopped, by the repetition of practices from many decades ago.

According to Poblete et al. (2013), the academic achievement of students in the region is not good. Approximately one-third of students in primary school and less than half in secondary school have not achieved the minimum required learning in reading, as well as in mathematics, where the results are less satisfactory. Thus, one of the important factors in the management of innovation and educational quality is information technologies (Poblete et al. (2013). In this sense, the UNESCO report states that ICTs should be used to foster modern competencies and increase student performance, to achieve educational quality that will have an impact on innovation.

Undoubtedly, technology has advanced outstandingly in recent years, but this does not mean that an ideal scenario is close to being achieved in the educational sector, specifically in regular basic education, both in the use, acceptance, and exploitation of technologies and in the use of new technologies (García-Peñalvo, 2016). Teaching and learning processes in institutions have generated that information systems have evolved into what are now called technological ecosystems. The technological ecosystem is the set of people and elements of hardware, software, networks, etc., and a set of information flows that determine the relationship between the software elements and the people involved in the technological ecosystem (García-Peñalvo, 2018).

According to Baumann et al. (2016), for educational innovation management, the company that includes a subset of innovations (innovation portfolio) must understand the systemic nature of these innovations, the complexity of the system, and the dynamic nature of the elements of the innovation system (stakeholders, structure, organization, processes, products, etc.) i.e., the technological ecosystem.

At the regional level and specifically in the mining camp schools of southern Peru, innovation management is affected, and there is a repetition of methodologies from previous years and in some cases decades. Aguilar-Forero & Cifuentes (2020) also indicate that although educational innovation management is constantly growing at the international level, the effects and configurations in certain contexts are still unknown. It is necessary to know how the technological ecosystem influences innovation management in education in mining camp schools in southern Peru. Sanchez et al. (2017) also consider it important to know how the technological infrastructure influences innovation management.

Within the technological ecosystem, there are diverse benefits and requirements, there is a set of infrastructures and services, as well as the interaction of those involved (Bello, 2016), we are facing a value chain that becomes a subject of analysis (Katz, 2015), of which we must understand and know-how information, content, architecture, social behaviors, forms of consumption of technology, the active participation of the consumer,

and finally the process of digitization is generated, it is necessary to know all these indicators and the influence it has on the management of innovation.

The general objective is to determine the influence of the technological ecosystem in the management of innovation in Peruvian schools; and the specific objectives are: To identify the influence of technological infrastructure on innovation management, to establish the influence of technological availability on innovation management, and to analyze the influence of technological accessibility on innovation management in Peruvian schools.

Regarding the theoretical framework of the technological ecosystem, some definitions stand such as Garcia-Peñalvo & Garcia-Holgado (2016), who point out that they must have the ability to recognize a complex network of independent interrelationships between the components that make up its architecture while offering an analytical framework to understand the specific patterns of evolution of its technological infrastructure. Also, Garcia-Holgado & Garcia-Peñalvo (2017), specify that it is a model that can be used for any type of solution, these are the evolution of traditional information systems, in their work aims to create a metamodel that defines learning ecosystems focused on knowledge management, and Mendonca & Smith (2021) who describe that technological accessibility refers to the ability of people to access and use technology effectively and without barriers, regardless of their abilities, disabilities, age, gender or any other characteristic.

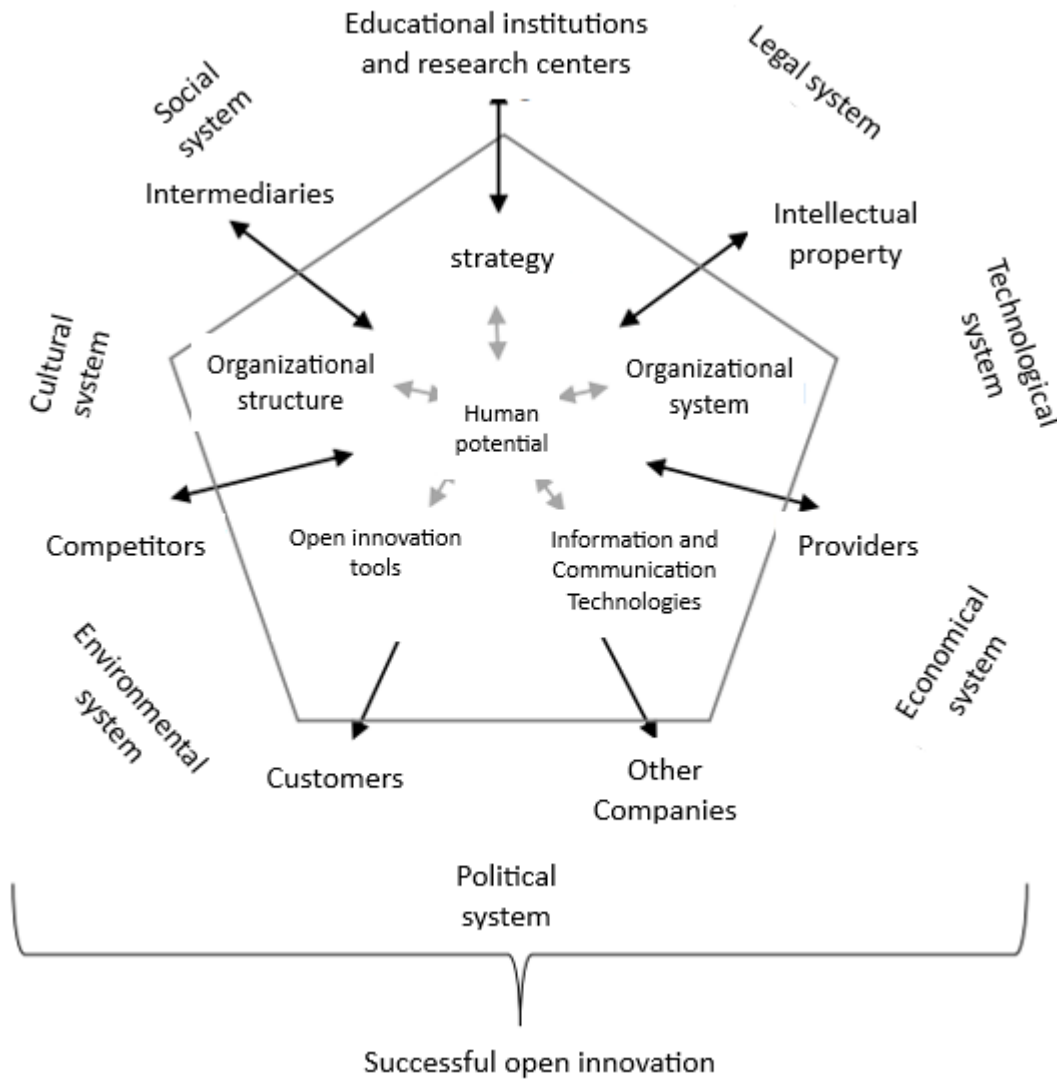
Several theories focus on explaining how companies, users, and technologies interact to create a complex and constantly changing environment:

- Platform theory: This theory focuses on the creation of technology platforms that enable the creation of an ecosystem of applications and services. According to this theory, technology platforms act as intermediaries that connect users with application and service developers (Parker et al., 2016).
- Network theory: This theory focuses on the importance of networks and the interconnection of devices in the technological ecosystem. According to this theory, the interconnection of devices enables the exchange of information and the creation of new business opportunities (Newman et al., 2006).
- Open innovation theory: This theory focuses on the importance of collaboration and open participation in the technological ecosystem. According to this theory, innovation occurs through collaboration between companies, universities, developers, and users (Chesbrough, 2003).
- Evolution theory: This theory focuses on the idea that the technological ecosystem continuously evolves and adapts as users and companies interact. According to this theory, the technological ecosystem is constantly changing and evolving, and companies must adapt to survive (Pérez, 2005).

Currently, the relevance of people in companies in innovation is unquestionable, whatever the line of business, including education, individual and collective knowledge, and acquired knowledge, as well as that which is incorporated contributes to the development of new skills, new ways of performing and making use of technological resources, as well as new forms of business management (Álvarez-Aros & Bernal-Torres, 2017). The determinants of the competitive capacity, as well as the innovation management of companies, are highlighted by human talent as the main factor because it is the main actor that gives a distinctive and sustainable advantage to institutions, as well as being the dynamizing factor of other factors. The efficiency in the use of tangible and intangible resources of the companies depends on the potential of the people who work in them.

It is through the development and use obtained by people, and not by people themselves, that resources in institutions and the environment are used to create and use innovations to build competitive advantage and generate quality in the services or products they provide; therefore, it is considered that institutions must ensure the conditions for people to develop, adopt and use their potential to identify, create and use innovation as an added value to improve the quality of the service or product.

Figure 1 Open innovation model in the technological ecosystem



Note. Developed by Álvarez-Aros and Bernal-Torres (2017).

The dimensions used are as follows:

- Technological infrastructure: The importance of information technologies today plays an important role as a tool used in the service activities of business organizations. It is considered that achieving high efficiency and effectiveness in organizations requires investment in technological infrastructure, such as internet, office automation and management systems, as it serves as the basis for information technology, communications and data systems, within the technical framework that guides organizational work to meet management needs. Finally, an IT infrastructure is the foundation on which a company can provide reliable services through an organized and coordinated central information system. It is important to adopt a method of classifying the support provided by information technologies so that the organization can have a competitive advantage:

hardware, software, networks and communications, human resources and databases are some of the physical components and used in information processing, especially machinery such as computers, data carriers and other tangible things to record information and be able to provide services to users (Jabbouri et al., 2016).

- Technological availability: The ability of a system or technological resource to be available and function properly at all times, without interruptions or failures that may affect its use or user satisfaction; Malek et al. (2008) refer that the issue of technological availability and its analytical assessment in IT services are critical in the use of ICT, it is stated that the availability of IT services is critical to the success of any organization in today's digital economy. Under an analytical assessment of technology availability, which involves the use of mathematical models and techniques to calculate the probability that an IT service will be available at any given time. It is the ability of an organization to maintain the functionality and performance of its ICT systems and services at all times, which is essential to the success of organizations in today's digital economy, as ICT systems and services are increasingly critical to most aspects of business, from human resource management to finance, supply chain and marketing, most functions of an organization depend on ICT systems and services for their execution (Weill & Ross, 2009).
- Technological accessibility: Technology is considered a cultural tool that has the potential to amplify and reorganize cognitive processes; but we must clarify that the realization of this potential depends largely on the relationship established with it. Technological accessibility at work or study has a positive effect on productivity and performance, but also a potential negative effect of overload and distraction. Information and communication technologies are not homogeneous, and each tool is used differently. Students with technological accessibility seem to obtain better results in standardized tests, but those results depend on the type of device, how they are used and the specific educational context (Martínez-Gautier et al. 2021) therefore, although access to technology at school can potentially improve the teaching and learning process, as well as increase the motivation of students and teachers, there is no clear evidence of how these technological resources should be presented, nor of the concrete impact. It refers to the ability of individuals to access and use technology effectively and without barriers, regardless of their abilities, disabilities, age, gender or any other characteristics (Mendonca & Smith, 2021).

Regarding the theoretical framework of innovation management, some definitions stand out, such as Drucker's (2014), who states that innovation is a fundamental responsibility of managers, emphasized the importance of innovation in business management, and argued that innovation management should be treated as a key function of business management, and stressed that innovation can come in many forms, including product and service innovation, process innovation and organizational innovation. An understanding of how companies can create and manage innovation that enable them to develop and maintain their competitive advantage is important, considering the business platform as a set of interconnected and standardized components, which allow users to access a variety of complementary products and services (Gawer & Cusumano, 2014); they further note that innovation management enables institutions to leverage the knowledge and creativity of users to develop innovative products and services.

The dimensions used are as follows:

- Strategy: Christensen et al. (2006) stressed the importance of strategic innovation management, rather than simply focusing on short-term innovation, and argued that companies should invest in research and development and have a clear

innovation strategy that adapts to changes in the market and technology. It is necessary to highlight the importance of established companies recognizing and responding to disruptive innovations effectively in order to maintain their competitive advantage. Importance should also be given to innovation based on customer need. Companies should focus on understanding the needs and desires of their users in order to develop innovative products and services that effectively meet those needs.

- **Deployment:** Rogers (2010) indicates that innovation deployment refers to the process by which new technologies or ideas are adopted and diffused in a society or organization. Within innovation, there is the role of organizational leadership, culture and practices in the effective deployment of innovation in companies. The effective deployment of innovation is driven by several factors, where leaders must be committed to innovation and have a clear and coherent vision of what they want to achieve, in addition, they must establish clear goals for innovation and foster a culture of experimentation and learning. Organizational culture is also important for the effective deployment of innovation, companies that value innovation and encourage creativity and innovative thinking are more likely to be successful in deploying innovation; in addition, companies that have a collaborative culture and encourage cross-functional collaboration are more likely to be innovative.
- **Culture:** In an increasingly competitive and changing business environment, the ability to innovate has become a necessity for companies that want to survive and thrive in the long term, innovation culture refers to the set of values, attitudes, beliefs and practices that promote and foster innovation within an organization. An innovation culture can help companies generate new ideas, improve their existing processes, products and services, and adapt quickly to market and industry changes (Schein, 2010). Creating a culture of innovation starts with leadership, company leaders must be committed to innovation and demonstrate their commitment through their actions and decisions, they must establish a clear and coherent vision of what they want to achieve through innovation and communicate it effectively throughout the organization. A culture of innovation is essential for companies to survive and thrive in today's business environment; creating a culture of innovation begins with committed leadership and is based on values such as experimentation, collaboration and continuous improvement.
- **Innovation:** According to Suárez et al. (2020) innovation is related to many aspects within the organization and the world, it can be affirmed that the capacity to generate, use and disseminate innovations is a strategic element in the new world order. It should be noted that the innovative dynamic is not restricted to a single organization or a single sector, it is strongly related to multiple activities and capabilities. Being the responsibility of the institutions, of their chains and service areas, and of the other economic and non-economic actors that make up the different production systems, as well as the environments in which they are inserted. García-Peñalvo (2016) proposes that one of the categories of educational innovations is the management of innovation itself as well as the technological ecosystem, aligned with the university's strategy and governance. Educational innovation can be understood as the process of improvement in learning. On the other hand, the influence of technologies in people's daily activities causes a transfer, conscious or not, to their professional and/or educational context.

MATERIAL AND METHODS

The research has been defined as basic with a quantitative approach, due to the fact that it seeks to know how the technological ecosystem influences the management of innovation in basic education in Peru, and to explain the intervening factors (Hernández et al., 2014, p. 48); the level is explanatory, the design is non-experimental, the scope of study is the schools located in the mining camps in southern Peru, the unit of study is composed of the personnel who are users and have access to technology and innovation in the schools.

A stratified random sampling was used, considering a confidence level of 97%, $z=2.17$, variability of $p=0.5$, error at 5%, population size of 215 workers, the sample is 148 workers, distributed as follows:

Table 1 Number of personnel per school (sample)

N°	Name of school	Location	Personal
1	Enrique Meiggs	Ilo – Moquegua	30
2	Juan Vélez de Córdova	Cuajone – Moquegua	30
3	Mariscal Ramón Castilla	Toquepala – Tacna	30
4	Fiscalizado Toquepala	Toquepala – Tacna	29
5	Daniel Alcides Carrión	Cuajone – Moquegua	29
Total			148

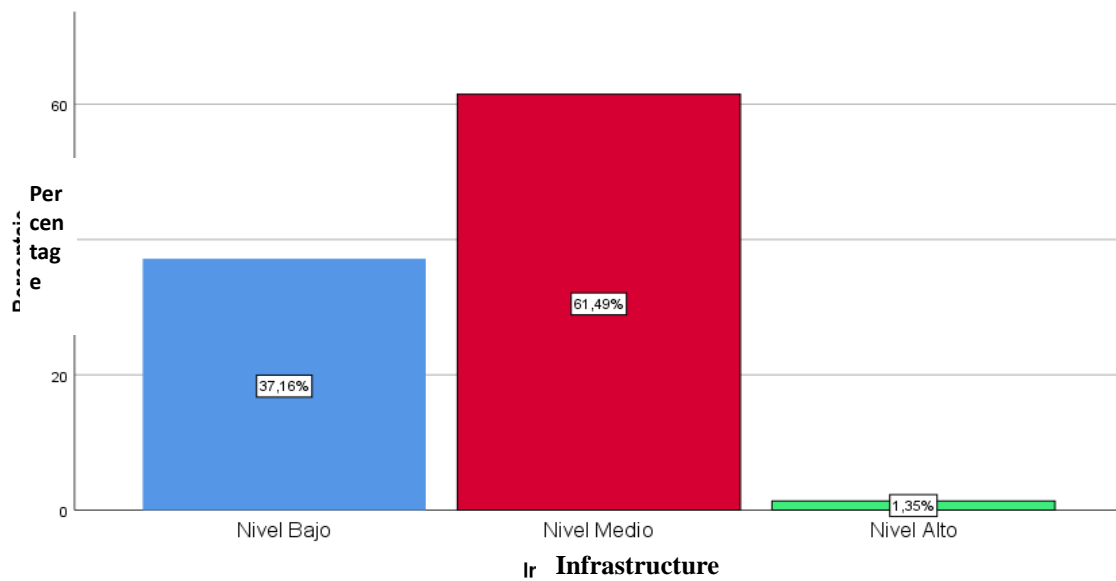
Note. Own elaboration

The technique was the survey; for the independent variable Technological Ecosystem, the questionnaire of Moral-Pérez et al. (2020) which contains 17 questions for the infrastructure dimension, 07 questions for the Availability dimension and 05 questions for the Accessibility dimension; for the dependent variable Innovation Management, the questionnaire of Sossa & Zarta (2013) was adapted, which contains 04 questions for the strategy dimension, 04 questions for the deployment dimension, 04 questions for the culture dimension and 06 questions for the Innovation dimension; Likert type questions from 1 to 5 being 1 = Never, 2 = Almost Never, 3 = Occasionally, 4 = Almost Always and 5 = Always. The Cronbach's alpha was 0.965 (Technological Ecosystem variable) and 0.960 (Innovation Management variable).

RESULTS

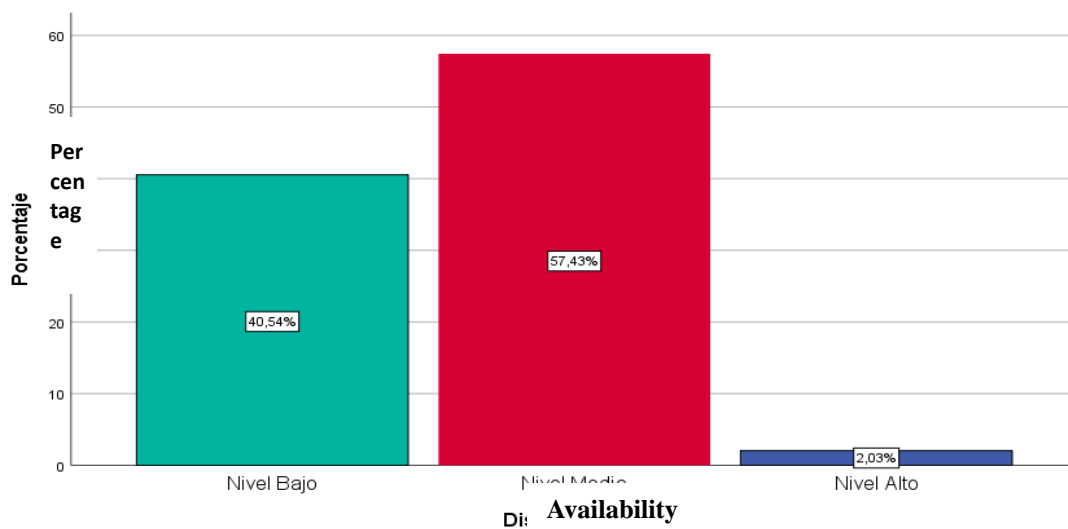
Regarding the variable “Technological Ecosystem”, graphically, the results indicate that the respondents state that the highest percentage of the infrastructure in schools in mining camps in southern Peru is 61.49% considering that it is of medium level, followed by the low level with 37.16% and finally the high level with 1.35%.

Figure 2 Results of the technological infrastructure dimension.



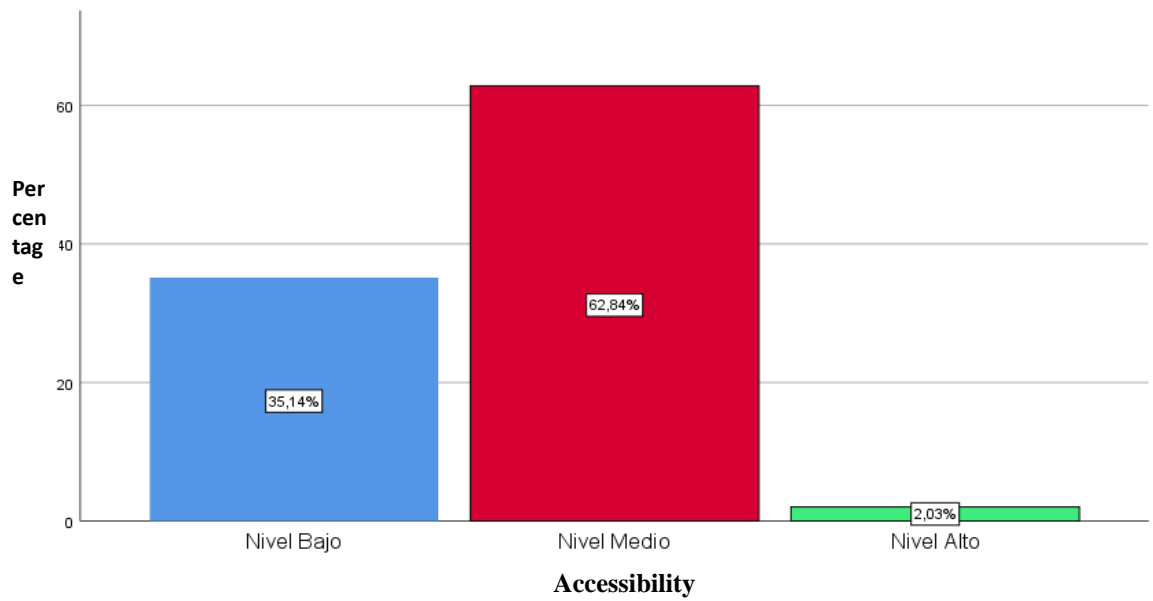
The results indicate that the respondents stated that with respect to technological availability in schools, the highest percentage is 57.43% considering it to be medium level, followed by Low level with 40.54% and finally High level with 2.03%.

Figure 3 Results of the technological availability dimension.



It is observed that the results indicate that the respondents state that with respect to technological accessibility in schools, the highest percentage is 62.84% considering that it is of medium level, followed by the Low level with 35.2%, and finally the High level with 2.03%.

Figure 4 Results of the technological accessibility dimension



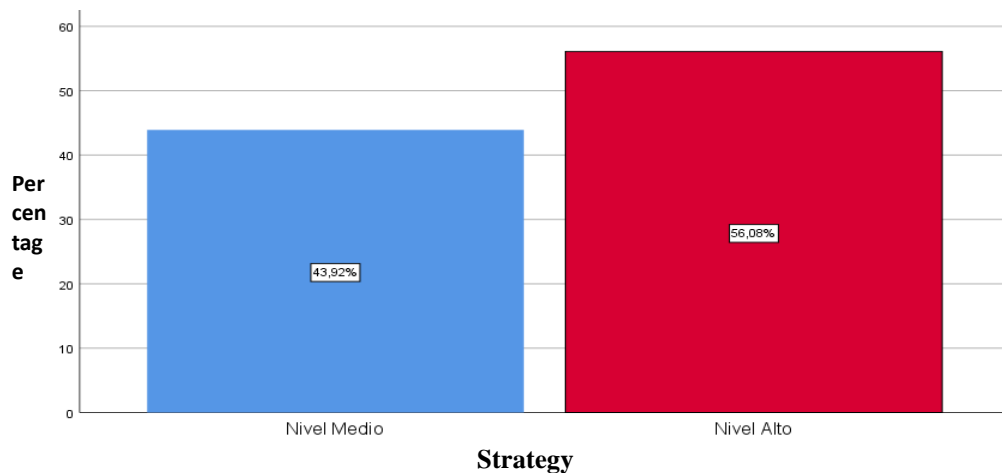
The results for the independent variable Technological Ecosystem show that 34.5% of the respondents stated that the level of the Technological Ecosystem in the mining camp schools in southern Peru is Low, while 64.5% consider the level to be Medium, and finally, only 2.0% consider the level of the Technological Ecosystem to be Low.

Table 1 Results of the technological ecosystem variable.

Level	Frequency	Percentage
Low Level	51	34.5
Medium Level	94	63.5
High Level	3	2.0
Total	148	100.0

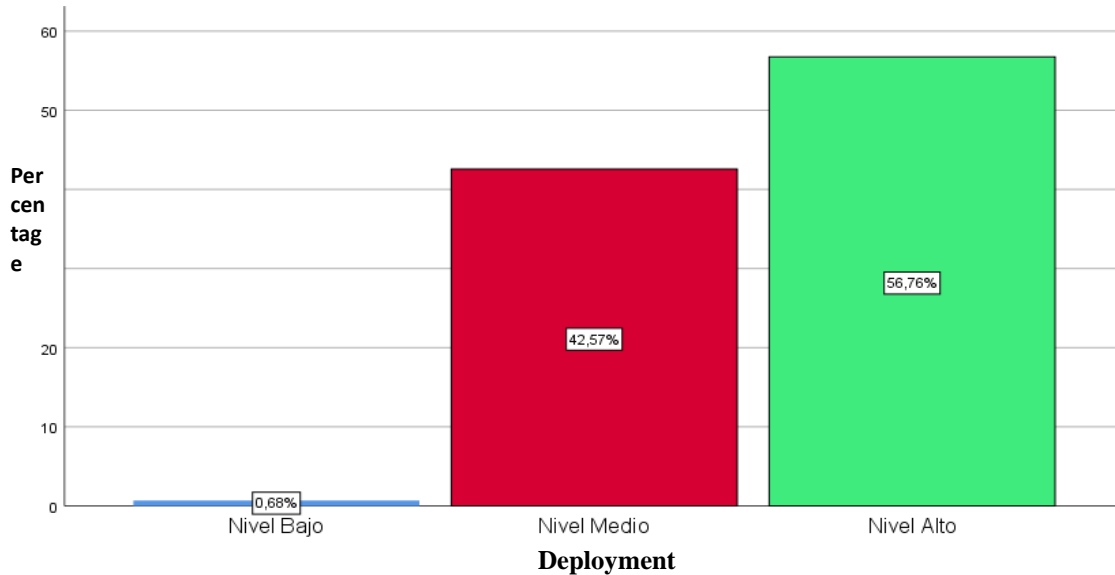
Regarding the variable “Innovation management”, the results show that the highest percentage of respondents in schools in mining camps in southern Peru is 56.08% considering that it is at a high level, followed by the medium level with 43.92% and finally the low level with 0.0%.

Figure 5 Results of the strategy dimension.



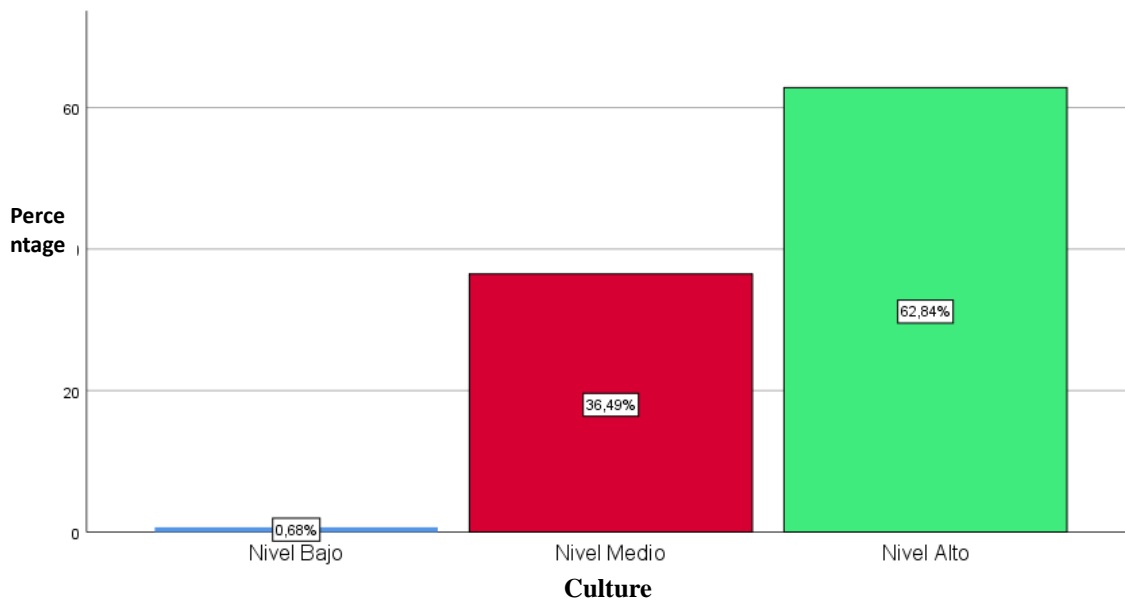
The results indicate that the respondents stated that with respect to the deployment in schools in mining camps in southern Peru, the highest percentage is 56.76% considering that it is at a high level, followed by the medium level with 42.57%, and finally the low level with 0.68%.

Figure 6 Results of the deployment dimension.



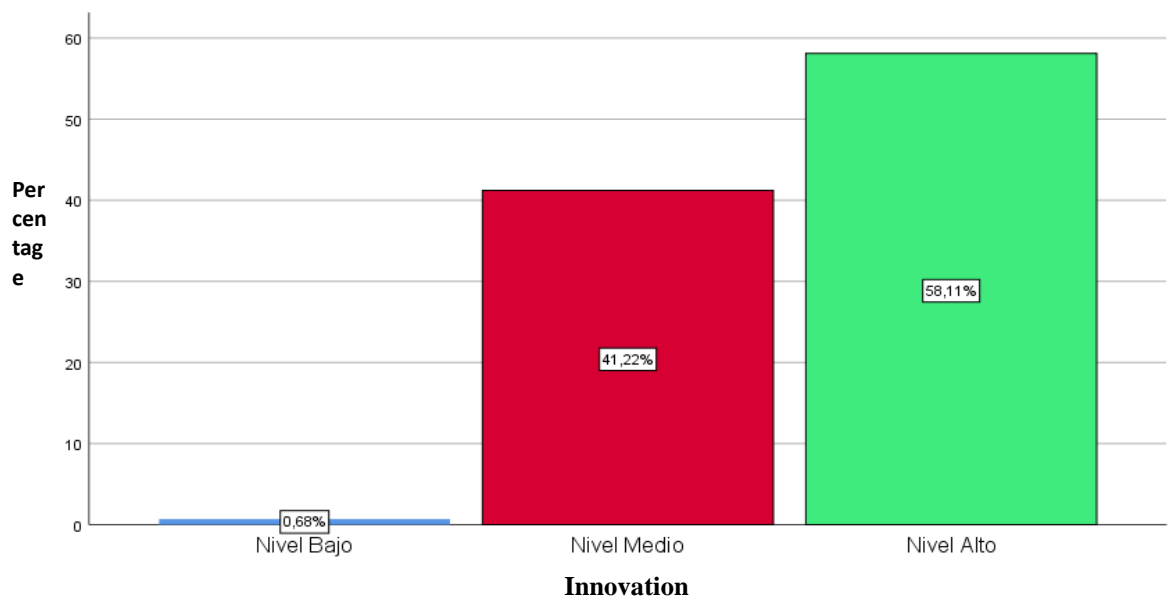
The results indicate that the respondents stated that, concerning technological accessibility in schools, the highest percentage is 62.84% considering it to be at the High level, followed by the medium level with 36.49%, and finally the Low level with 0.68%.

Figure 7 Results of the culture dimension.



The results indicate that the respondents state that with respect to the innovation dimension in schools, the highest percentage is 58.11% considering it to be at the High level, followed by the medium level with 41.22% and finally the Low level with 0.68%.

Figure 8 Results of the innovation dimension.



Regarding the variable “Innovation management”, according to the results obtained, 25.0% of the respondents stated that the level in mining camp schools in southern Peru is medium, while 75.0% consider the level to be high, and 0.0% consider the level of infrastructure to be low.

Table 3 Result of the innovation management variable.

Level	Frequency	Percentage
Low Level	0	0.0
Medium Level	37	25.0
High Level	111	75.0
Total	148	100.0

The specific hypothesis test 1:

H_0 : Technology infrastructure does not influence innovation management in schools.

H_1 : Technology infrastructure influences innovation management in schools.

The pseudo- R^2 Nagelkerke indicates that 59.5% explains the variability; a “p” value of less than 0.05 was obtained, so H_0 is rejected, where technological infrastructure significantly influences innovation management in mining camp schools in southern Peru.

Table 4 Ordinal regression on specific hypothesis 1

Pseudo R^2	
Cox y Snell	0.594
Nagelkerke	0.595
McFadden	0.141

Table 5 Specific hypothesis testing 1

Model fit information				
Model	Log likelihood logarithm 2	Chi-square	gl	Sig.
Intersection only	641.288			
Final	507.801	133.486	29	0.000

The specific hypothesis test 2:

H₀: Technology availability does not influence innovation management in schools.

H₁: Technology readiness influences innovation management in schools.

The pseudo-R² Nagelkerke indicates that 48.7% explains the variability; a “p” value of less than 0.05 was obtained, so H₀ is rejected, where technological availability significantly influences innovation management in mining camp schools in southern Peru.

Table 6 Ordinal regression on specific hypothesis 2

Pseudo R ²	
Cox y Snell	0.486
Nagelkerke	0.487
McFadden	0.104

Table 7 Specific hypothesis testing 2

Model fit information				
Model	Log likelihood logarithm -2	Chi-square	gl	Sig.
Intersection only	561.198			
Final	462.706	98.492	16	0.000

Specific hypothesis testing 3:

H₀: Technological accessibility does not influence innovation management in schools.

H₁: Technological accessibility influences innovation management in schools.

The pseudo-R² Nagelkerke indicates that 46.9% explains the variability; a “p” value of less than 0.05 was obtained, so H₀ is rejected, whereby technological accessibility significantly influences innovation management in mining camp schools in southern Peru.

Table 8 Ordinal regression on specific hypothesis 3

Pseudo R ²	
Cox y Snell	0.468
Nagelkerke	0.469
McFadden	0.098

Table 9 Specific hypothesis testing 3

Model fit information				
Model	Log likelihood logarithm -2	Chi-square	gl	Sig.
Intersection only	499.466			
Final	406.096	93.370	14	0.000

The general hypothesis test:

H₀: The technological ecosystem does not influence innovation management in schools.

H₁: Technological ecosystem influences innovation management in schools.

The pseudo-R² Nagelkerke indicates that 60.5% explains the variability; a “p” value of less than 0.05 was obtained, so H₀ is rejected, where the technological ecosystem significantly influences innovation management in mining camp schools in southern Peru.

Table 8 Ordinal regression on the specific hypothesis 3

Pseudo R ²	
Cox y Snell	0.604
Nagelkerke	0.605
McFadden	0.144

Table 9 Specific hypothesis testing 3

Model fit information				
Model	Log likelihood logarithm -2	Chi-square	gl	Sig.
Intersection only	721,175			
Final	584,197	136,977	41	0,000

DISCUSSION

The results of the present research allow determining that infrastructure, availability and accessibility, as well as the technological ecosystem influence the management of innovation in mining camp schools in southern Peru; this by obtaining the pseudo-R² Nagelkerke 60.5%; for Tsujimoto et al. (2018) in the conclusions of his research states that the objectives were to find the principles of decision-making and behavioral chains that greatly affect the growth and decline of the ecosystem. From these theoretical foundations, create schemes and processes to investigate manage and design/redesign both new and existing ecosystems. In this way our research has determined that internal and external aspects such as infrastructure, accessibility and availability are related to innovation management, not only that, it has been determined that explain the behavior of innovation management, and as the authors state it is important to know what other aspects influence the management of innovation and the improvement of the technological ecosystem.

Sossa & Zarta (2013) conclude that in the structure, acquisition and planning of technology there are still gaps that need to be studied and determined, this agrees with the findings of our research, although the hypothesis was accepted. It has been determined that the level of the technological ecosystem is at a medium level with 63.50%, which is consistent with the fact that there are additional mechanisms to guarantee innovation and

that these guarantee high levels of impact. These still need to be worked on and investigated.

Gupta et al. (2019), regarding the word's entrepreneurial ecosystem, innovation ecosystem and digital ecosystem, as well as other related ones, concludes that it is important for future research to analyze the concepts of the words beyond the flashy titles, in appendix A of his work he mentions the redundant words that he eliminates in his study. This is coincident with the present research that has been found that the technological ecosystem is in our language, but in English it is called digital ecosystem, as well as innovation is called innovation ecosystem in many research. Finally, it is agreed that it is important to consider the comparison of terms in the different research since this influences the directions or management of innovation in the companies.

Albornoz-Barriga (2019) concludes that the ecosystem aims to promote and strengthen educational innovation through the exchange of knowledge and experiences among teachers, highlights a new factor that is the sociomaterial, in which he mentions that people and objects are assembled or not assembled, this factor has not been considered in our research, being infrastructure, availability and accessibility the main factors that have been considered as components of the technological ecosystem and influential in innovation management.

García-Peñalvo (2018) concludes that although technology is not the end, today it is an essential means to innovate and evolve. Thus, he also states that the concept of information system has been surpassed and it is necessary to have new definitions and concepts of what a technological platform is, finally he refers that as a solution to this new need he proposes the metaphor of the technological ecosystem, which will allow building learning ecologies according to the advances of society. This coincides with the present investigation since it has been determined that, if there is influence in the technological ecosystem towards the management of innovation, as well as the dimensions that have been determined and those that should be further investigated to improve the model that adjusts more in the improvement of innovation management.

CONCLUSIONS

There is a significant influence of the technological ecosystem on innovation management in schools in mining camps in southern Peru, since the “p” was found to be less than 0.05, in addition to the pseudo-R² of Nagelkerke of 60.50%; the findings determine that there is competitiveness due to the high level of innovation management in 75%, and also denotes the influence of the technological ecosystem where it could be found at a medium level at 63.5% which highlights the investment and recognition of the architecture for the improvement of technological services in the institution.

Technological infrastructure has a significant influence on innovation management in schools in mining camps in southern Peru, since the p-value was found to be less than 0.05, and the Nagelkerke pseudo-R² was 59.50%.

Technological availability has a significant influence on innovation management in schools in mining camps in southern Peru, since the “p” was found to be less than 0.05, and the Nagelkerke pseudo-R² was 48.70%.

Technological accessibility significantly influences innovation management in schools in mining camps in southern Peru, since the “p” was found to be less than 0.05, and the Nagelkerke pseudo-R² was 46.90%.

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