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GATIC R model for managing Technology and Informatics learning through Moodle in rural primary education

Modelo GATIC R para la gestión del aprendizaje de Tecnología e Informática mediado por Moodle en la básica primaria rural

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ABSTRACT

Rural schools in Colombia adopt digital platforms with scarce equipment and unstable connections, since their students' technological competence depends on the classroom as much as on the territory. The study therefore aimed to model a management system for teaching and learning Technology and Informatics through Moodle, in order to strengthen the technological competences of fifth graders at a school in Arboletes, Antioquia. A mixed, projective and non-experimental approach was used, with students, teachers and two experts as informants. The results showed uneven development, with high attitude, intermediate functional use and weak conceptual mastery, and an expert rating of 114 out of 120 points. It was concluded that the GATIC R Model links diagnosis, teacher mediation and rural feasibility, and requires implementation to measure its effects.

Descriptors: educational technology; primary education; rural education; life skills; e-learning. (Source: UNESCO Thesaurus).

RESUMEN

Las escuelas rurales de Colombia incorporan plataformas digitales con equipos escasos y conexión irregular, por cuanto la competencia tecnológica de sus estudiantes depende tanto del aula como del territorio. Es así que el estudio se planteó como objetivo modelar un sistema de gestión para la enseñanza y el aprendizaje de Tecnología e Informática mediado por Moodle, en procura de fortalecer las competencias tecnológicas de quinto grado en una institución de Arboletes, Antioquia. En este sentido se empleó un enfoque mixto, proyectivo y no experimental, teniéndose como informantes a estudiantes, docentes y dos expertos. Entre los resultados se obtuvo un desarrollo desigual, con actitud alta, uso funcional intermedio y dominio conceptual débil, y una valoración experta de 114 sobre 120 puntos. Entre las conclusiones se estableció que el Modelo GATIC R articula diagnóstico, mediación docente y viabilidad rural, y requiere implementación para medir sus efectos.

Descriptores: tecnología educacional; enseñanza primaria; educación rural; competencias para la vida; aprendizaje en línea. (Fuente: Tesauro UNESCO).

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Research Articles Section

INTRODUCTION

When van Deursen & van Dijk (2019) analyzed, on the basis of a survey of the population of the Netherlands, how the first-level digital divide had evolved, they found that inequalities were shifting from physical access to the internet toward material access, understood as the quantity and quality of the devices, subscriptions and equipment each person has, and in doing so they set out a problem that is experienced daily in rural Colombia, since the arrival of computers, tablets or platforms does not in itself guarantee better learning and may instead widen the gap between those who have equipment in good condition and a stable connection and those who depend on an intermittent network. In line with this warning, Ruiz & Gallagher (2025) analyzed CONPES document 3988 of 2020, with which Colombia outlined its policy on technologies for learning, and found that the rural school is described there mainly in terms of deficits and pending connectivity rather than its own pedagogical practices, so that the design of digital solutions tends to be conceived far from the classroom it seeks to transform.

For its part, the concept of digital competence that currently guides much educational research brings together knowledge, skills and attitudes, as Ilomäki et al. (2016) maintain when describing it as a boundary concept that circulates between policy and educational research, and this threefold composition requires assessing separately what students know, what they do with the device and the disposition with which they approach it. In fact, Pedaste et al. (2023) built a digital competence test for schoolchildren in Estonia with items and scales differentiated by area, while Tan et al. (2024) validated a digital learning competence scale for technical secondary students in China, and both studies agree that competence cannot be inferred from frequency of use, which is why a prior diagnosis is indispensable before any intervention.

As far as platforms are concerned, Moodle has a long track record, and Gamage et al. (2022), in a systematic review published in the *International Journal of STEM Education*, identified trends in its use for teaching and learning, with a predominance of studies in higher education and little presence of primary education. Likewise, Al-Fraihat et al. (2025) showed, based on the perceptions of university students, that interface design and ease of navigation influence the way the environment is used, whereas Mella-Norambuena et al. (2024) reviewed the theoretical and empirical models underlying teachers' use of learning management systems and noted that most focus on technology acceptance rather than on the pedagogical organization of the experience.

However, the adoption of these tools runs up against conditions that depend neither on the teacher nor on the student, and Mhlongo et al. (2023) synthesize this in an iterative review published in *Heliyon*, in which infrastructure, accessibility, teacher preparation and institutional culture appear as factors that condition the use of digital technologies in learning environments. Similarly, Barikzai et al. (2024) examined the adoption of e-learning in emerging economies and recorded poor connectivity, the cost of devices and the lack of technical support as recurring barriers, which helps explain why a platform designed for urban settings may lose its meaning when transferred to a rural school without first reviewing its conditions of use.

At the theoretical level, the problem can be read from the standpoint of Vygotsky's sociocultural mediation, which Rigopouli et al. (2025) take up for technology-enhanced learning design and which explains why students achieve with help what they cannot yet do alone. To this is added connectivism, whose relevance as a learning theory for the digital age is discussed by Goldie (2016), and which describes learning as the ability to establish connections among sources and resources. For their part, Mishra & Koehler's (2006) technological pedagogical content knowledge (TPACK) model requires content, pedagogy and technology to be articulated rather than added together, an idea that Bueno et al. (2023) extended toward new perspectives that include the context in which teachers make their decisions.

But how is the teaching of Technology and Informatics organized in a rural fifth grade when students show interest in digital resources and, at the same time, have few devices and an irregular connection? This question was the starting point of the study conducted at the Institución Educativa Miguel Vicente Garrido Ortiz, located in the municipality of Arboletes, in the Urabá subregion of the department of Antioquia, a setting that brings together the conditions described in the literature reviewed. Based on the above, the research aims to model a management system for teaching and learning in the area of Technology and Informatics as a means of strengthening technological competences among fifth-grade primary students at that school, with four specific

purposes: to identify the theoretical and empirical postulates that guide the design, to describe the current state of technological competences, to configure the system in Moodle and to assess its relevance through expert judgment.

METHOD

The research was framed within the pragmatic paradigm, which Morgan (2007) defends as an alternative to the opposition between paradigms by placing the research question and its practical consequences at the center of methodological decisions, so that the combination of numerical and textual data responded to the need to design a solution for a specific school problem. Accordingly, the analytical-synthetic method was used, which Rodríguez-Jiménez & Pérez-Jacinto (2017) describe as breaking the object down into its parts in order to then integrate them into an explanatory whole, with a mixed, projective approach and a non-experimental, descriptive and propositional design, under which the regular functioning of the institution was observed without introducing changes in the school organization.

The key informants were the fifth-grade primary students enrolled during the research period, whose parents or guardians signed the informed consent; teachers associated with the subject area or educational level, who contributed their experience regarding resources, connectivity and strategies; and two experts with training in educational technology, curriculum and the evaluation of proposals mediated by information and communication technologies (ICT). By contrast, students from other grades, participants without authorization and people without verifiable experience in the object of study were excluded, and the identity of all participants was protected through codes, in accordance with Law 1581 of 2012 on personal data protection in force in Colombia.

Five techniques were used to collect the information, each associated with a purpose and an instrument, as summarized in Table 1, which shows that the student questionnaire consisted of 24 items on a five-category scale, from never to always, complemented by objective questions on conceptual recognition, while the expert judgment rubric grouped fifteen criteria into three dimensions with scores from one to four.

Table 1. *Techniques, instruments and informants by specific purpose*.

Specific purpose	Technique	Instrument	Informant or source
1. Identify theoretical and empirical postulates	Documentary analysis	Matrix for analyzing prior studies and theories	Peer-reviewed studies and curricular references for the area
2. Describe the state of technological competences	Survey	24-item questionnaire (1-to-5 scale) and objective questions	Fifth-grade students
	Semi-structured interview	Interview guide	Teachers of the area or level
	Non-participant observation	Observation guide by levels	Technology and Informatics classes
3. Configure the system in Moodle	Analysis and synthesis of findings	Need-component correspondence matrix	Results of purposes 1 and 2
4. Assess the relevance of the system	Expert judgment	15-criterion rubric in three dimensions (1-to-4 scale)	Two experts in educational technology

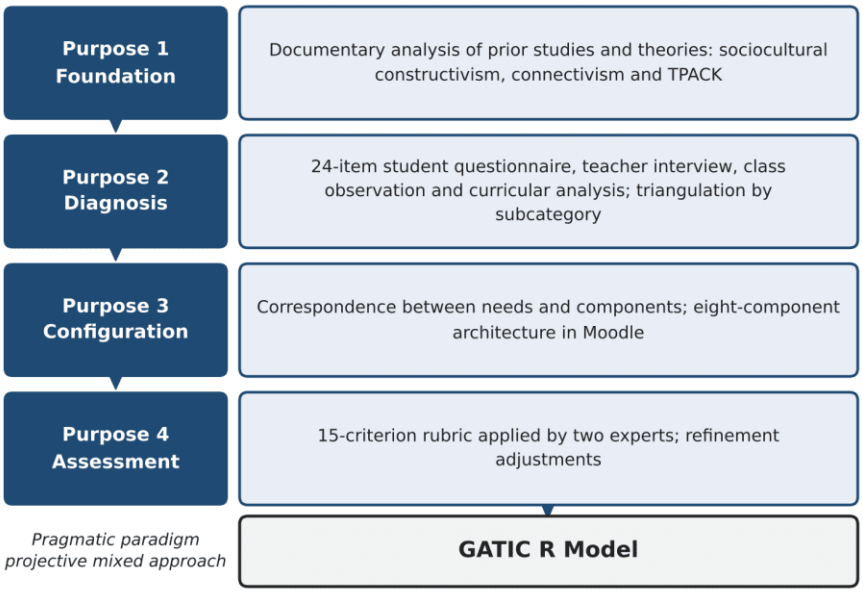
Note: developed in-house.

Regarding the analysis, the questionnaire data were processed using descriptive statistics with absolute and relative frequencies and percentages, while the interview and observation records were coded into previously defined categories and subcategories, following the five-phase process that Bingham (2023) proposes for moving from qualitative data management to actionable findings. Likewise, the documentary analysis of the curricular references for the area was conducted according to Bowen's (2009) criteria for examining documents as a source of evidence, and the final integration was carried out through triangulation among sources, so that each finding was confirmed or qualified with at least two different instruments.

Finally, the content validity of the instruments and the relevance of the system were estimated through expert judgment, a procedure that Escobar-Pérez & Cuervo-Martínez (2008) define as the informed opinion of people with experience in the subject who are recognized as qualified to issue judgments and assessments. Figure 1 shows the route followed, in which each specific

purpose produced inputs for the next and the expert assessment closed the design cycle, while the projective scope of the study did not include an implementation phase aimed at measuring changes in learning.

Figure 1. *Methodological route of the research*.



Note: developed in-house.

RESULTS

State of technological competences

The diagnosis revealed that the three subcategories of technological competence do not advance at the same pace, since students recognized the visible components of the computer, such as the monitor, keyboard or mouse, with relative confidence, but had difficulty distinguishing hardware from software, explaining what ICT are or identifying the school use of an educational platform and e-mail. So much so that, in the objective questions, recognition of hardware was adequate and identification of software was deficient, while the teacher interview pointed to the same confusion and the observation recorded low conceptual recognition alongside a medium level of initial device handling.

As regards functional use, students could use the computer in school activities, search the internet with guidance and access resources indicated by the teacher, although difficulties increased in organizing files, using the word processor, submitting evidence by digital means and carrying out multi-step procedures. According to the information gathered in the interview, playing videos or opening familiar applications was easy for them, so that technological autonomy appeared as a dimension still being consolidated and closely linked to the clarity of the instructions received.

By contrast, attitude toward technological learning was the subcategory with the best performance, given that the questionnaire showed interest in learning Technology and Informatics, motivation toward digital resources and confidence in exploring new tools, and the observation recorded high levels of participation and of requests for help. It should be noted that the teacher did not place lack of motivation among the main difficulties, but rather emphasized the constraints of equipment and connectivity, which made it possible to separate the desire to learn from the real opportunities for practice, as brought together in Table 2.

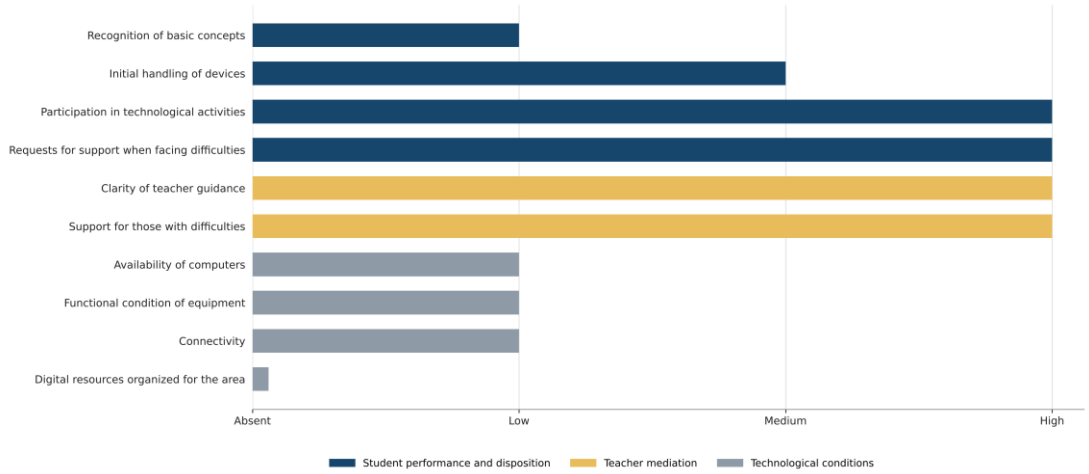
Table 2. *Triangulation of the state of technological competences by subcategory*.

Subcategory	Questionnaire and objective questions	Interview and observation	Integrated level
Technological conceptual mastery	Recognition of visible computer parts; uncertainty about hardware, software, educational platform and e-mail	Confusion between hardware and software; low conceptual recognition and medium device handling	Weak; requires conceptual structuring
Functional use of digital tools	Use of the computer, guided searching and access to indicated resources; difficulty with autonomous tasks	Ease with videos and familiar applications; difficulty with files, e-mail and platforms; high requests for support	Intermediate; dependent on guidance
Attitude toward technological learning	Interest, motivation, confidence and positive valuation of the area	Greater participation with computers, videos and interactive resources; high participation	High; motivational base that can be leveraged

Note: developed in-house from the questionnaire, the semi-structured interview, the observation and the documentary analysis.

Similarly, triangulation showed that the state of competences could not be separated from the conditions under which the area was taught, since the observation guide recorded low availability of computers, poor functional condition of the equipment and low connectivity, as well as the absence of organized digital resources for Technology and Informatics. In the face of these constraints, teacher mediation reached high levels both in the clarity of guidance and in the support given to those who had difficulties, so that Figure 2 shows, on a single ordinal scale, the contrast between the students' disposition, the teacher's response and the technological conditions of the school.

Figure 2. *Levels recorded in the observation guide for Technology and Informatics classes*.



Note: developed in-house from the non-participant observation guide.

Based on these records, Table 3 contrasts each factor with what was expressed in the teacher interview and with its impact on learning, which shows that high participation and guidance coexist with insufficient material access, and that neither condition alone explains the state of competences.

Table 3. *Factors of the teaching process associated with technological competences*.

Factor	Observation	Teacher interview	Identified impact
Availability of equipment	Low	Limited number of devices	Reduces individual and continuous practice
Connectivity	Low	Irregular connection	Conditions stable access to resources and platforms
Functional condition of equipment	Low	Operational limitations	Hinders the smooth development of activities
Organized digital resources	Absent	Need to organize materials	Scattered content and use of occasional resources
Teacher guidance	High	Constant support	Facilitates activities when difficulties arise
Student participation	High	Motivation toward digital activities	Favorable condition for strengthening competences

Note: developed in-house from the observation guide and the semi-structured interview.

Configuration of the management system in Moodle

Based on these findings, the system was configured in Moodle as an eight-component architecture, each derived from a specific need identified in the diagnosis, so that conceptual difficulties guided the selection of content, dependence on support gave rise to sequenced guidance, motivation toward visual material justified interactive resources and connectivity limitations determined criteria of contextual accessibility. Table 4 presents this correspondence among component, function and empirical basis, which shows that the platform was conceived as support for pedagogical decisions rather than as a repository of loose materials.

Table 4. *Architecture of the learning management system in Moodle*.

Component	Function in the system	Basis derived from the diagnosis
Content	Organize learning in the area of Technology and Informatics	Conceptual needs and curricular references
Digital educational resources	Represent and support understanding of the content	Student motivation and absence of organized materials
Activities	Promote practice, application and verification	Need to strengthen conceptual and functional use
Guidance	Guide procedures and learning paths	Partial dependence on teacher support
Navigation	Facilitate orderly access to the system	Level of technological autonomy observed
Interaction	Maintain the pedagogical relationship between teacher and student	Importance of the mediation identified
Monitoring	Record activities and support feedback	Need for progressive support
Contextual accessibility	Adjust resources to institutional possibilities	Connectivity and equipment available at the rural school

Note: developed in-house.

Assessment of relevance through expert judgment

As for the assessment, each of the two experts assigned 57 of the 60 possible points, equivalent to 95% of the maximum score and an overall mean of 3.8 out of 4, with a combined result of 114 out of 120 and a rating of relevant with minor adjustments, which ruled out a structural redesign. It should be noted that no criterion was rated as deficient or acceptable, since all scores fell between good and excellent, although the disaggregated reading of Table 5 shows that the three-point scores were concentrated in the comprehension of instructions, the accessibility of resources, the feasibility of the activities with institutional means and the consideration of connectivity.

Table 5. *Assessment of the relevance of the system by criterion and dimension*.

Dimension	Criterion	Expert 1	Expert 2	Mean
Pedagogical	Clarity and coherence of the learning objectives	4	4	4.0
	Suitability of the content for fifth grade	4	4	4.0
	Correspondence of the activities with technological competences	4	4	4.0
	Gradual teaching sequence	4	4	4.0
	Comprehension of the instructions	4	3	3.5
	Dimension mean	*4.0*	*3.8*	*3.9*
Technological	Clear and orderly navigation	4	4	4.0
	Functionality and accessibility of digital resources	3	4	3.5
	Feasibility of the activities with institutional resources	3	3	3.0
	Visual design suitable for the student	4	4	4.0
	Organization of resources, tasks and monitoring	4	4	4.0
	Dimension mean	*3.6*	*3.8*	*3.7*
Contextual	Fit of the system to rural conditions	4	4	4.0
	Consideration of connectivity and equipment availability	3	3	3.0
	Correspondence with students' real needs	4	4	4.0
	Capacity to support teacher planning	4	4	4.0
	Feasibility for future implementation phases	4	4	4.0
	Dimension mean	*3.8*	*3.8*	*3.8*
Overall	Total score (maximum 60 per expert)	57	57	3.8

Note: developed in-house. Rubric scale: 1 = deficient, 2 = acceptable, 3 = good and 4 = excellent. Both experts rated the system as relevant with minor adjustments.

According to the table, the pedagogical dimension obtained the highest mean, at 3.9, followed by the contextual dimension at 3.8 and the technological dimension at 3.7, and the lowest-scoring criterion was the feasibility of the activities with institutional resources, which received three points from both evaluators, as did the consideration of connectivity and equipment availability. It is noteworthy that navigation, visual design and the organization of tasks and monitoring reached the maximum mean of 4.0, so that the experts' reservations pointed to the material conditions of the setting in which the system was to operate rather than to the interface.

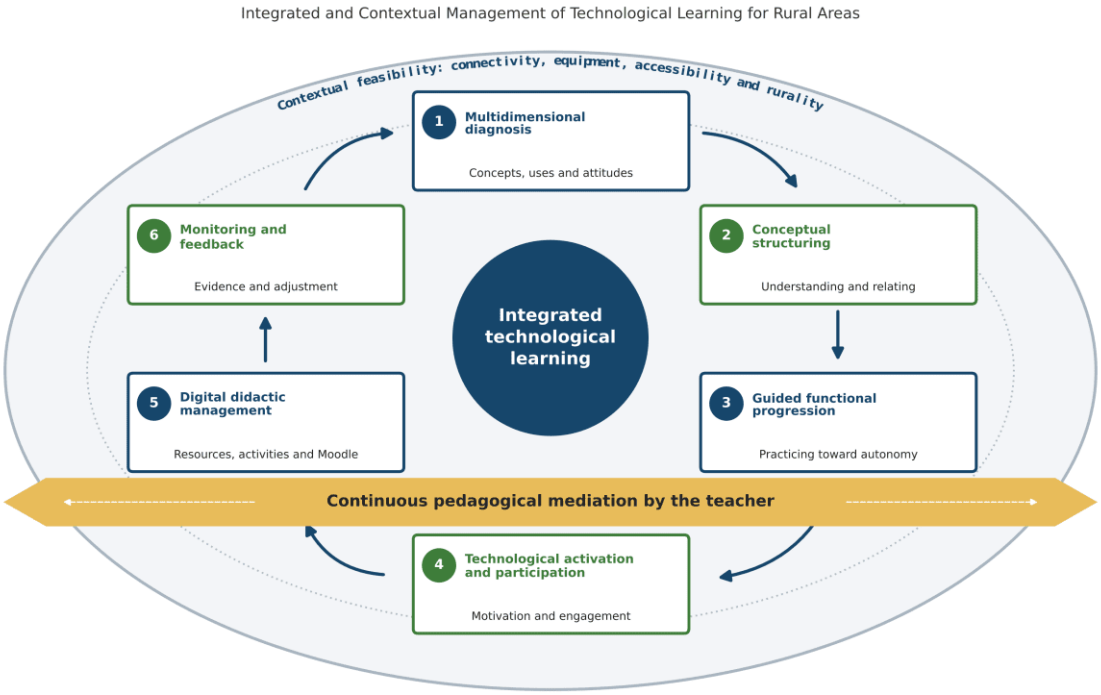
Consequently, the qualitative observations translated into refinement adjustments, including simplifying the wording of some instructions for primary students, reducing the file size of certain audiovisual resources, incorporating downloadable materials and providing alternative activities for days of limited connectivity. By contrast, the objectives, content, competence categories, didactic organization and monitoring mechanisms were kept, since the experts rated them with the maximum score and modifying them was not supported by the diagnosis.

GATIC R Model

From the integration of the four purposes, the GATIC R Model was formulated, an acronym for Gestión del Aprendizaje Tecnológico Integrado y Contextual para la Ruralidad (Integrated and Contextual Management of Technological Learning for Rural Areas), which organizes within a single structure the student's competences, the disciplinary knowledge of the area, pedagogical mediation, Moodle's functionalities and the access conditions of the rural school. As for its nature, it is pedagogical, technological, contextual and projective, and far from constituting a new learning management system or an isolated teaching sequence, it offers an architecture that indicates how to use the platform on the basis of the prior diagnosis, as represented in Figure 3.

Figure 3. *GATIC R Model for integrated and contextual management of technological learning in*

rural areas.



Note: developed in-house.

In the figure, the six components revolve around integrated technological learning, from the multidimensional diagnosis of concepts, uses and attitudes to monitoring and feedback, which return the cycle to its starting point, while the teacher's continuous pedagogical mediation runs through the entire process and contextual feasibility surrounds it because it conditions every technological decision. Likewise, Table 6 sets out the nine guiding principles of the model, whose formulation stems from the findings and the theoretical references, and which serve as criteria for adapting the system to other content, other grades or institutions with similar conditions.

Table 6. *Guiding principles of the GATIC R Model*.

Principle	Description
Diagnosis before design	Pedagogical and technological decisions start from the actual state of competences
Disciplinary articulation	Digital resources are selected according to the learning goals of the area
Progression	Activities move from explicit support toward greater levels of autonomy
Mediation	The teacher remains the guide and is responsible for feedback
Integration	Content, pedagogy and technology are organized in an articulated way
Participation with purpose	Motivating resources are always linked to a learning purpose
Accessibility	Technological decisions are adjusted to equipment, connectivity and institutional possibilities
Monitoring	The system produces evidence that makes it possible to recognize progress and needs
Adaptability	The structure allows adjustments according to curriculum, population and available resources

Note: developed in-house.

DISCUSSION

The uneven development among attitude, functional use and conceptual mastery coincides with the structure of digital competence described by Ilomäki et al. (2016), for whom knowledge, skills and attitudes form a unit that does not advance as a block, and with the methodological decision of Pedaste et al. (2023) to measure each area of competence separately in schoolchildren. Nevertheless, the findings in Arboletes add a nuance, since everyday familiarity with videos and applications gave students reference points for use, but not the conceptual organization that would allow them to distinguish a program from a device, which indicates that it is naive to assume that frequent contact with technology is equivalent to understanding it.

With regard to mediation, dependence on teacher support in multi-step tasks is explained by the notion of the zone of proximal development that Rigopouli et al. (2025) transfer to the design of technology-enhanced environments, in which the help of the adult or the more capable peer is gradually withdrawn as the student gains autonomy. In turn, Runge et al. (2023) found in Germany that teachers' beliefs about their own digital competence are related to the instructional quality they report in technology-enhanced lessons, especially to their capacity to give students autonomy, which is why the GATIC R Model keeps the teacher as a guide and does not replace them with the platform.

Moreover, the maximum rating given to navigation and visual design is consistent with the findings of Al-Fraihat et al. (2025), who linked the perception of Moodle with the quality of its design, and with the proposal by Ngulube & Ncube (2025) to use learning analytics to improve the user experience in these systems. However, both studies were conducted in higher education, so the contribution of the present work lies in showing that, in a rural fifth grade, a simple and uniform structure across units matters as much as aesthetics, given the level of technological autonomy observed in the students.

Regarding motivation, Lampropoulos et al. (2025) reviewed gamification in learning management systems and found favorable effects on participation, although these were conditioned by the design of the activities, while Alshammary & Alhalafawy (2023) gathered in a meta-analysis evidence of improvements in learning outcomes associated with the use of digital platforms. The purpose of this is to point out that the high interest of the students in Arboletes is a condition that can be leveraged, but not an outcome, which is why the principle of participation with purpose requires every motivating resource to be tied to learning in the area.

Another aspect that should be examined is the weight of infrastructure, since the scores of three for connectivity and for feasibility with institutional resources confirm what Mhlongo et al. (2023) and Barikzai et al. (2024) describe as structural barriers to technology adoption in low-resource contexts. On this point, Ruiz & Gallagher (2025) question the fact that Colombian policy imagines the rural school only as a recipient of connectivity, and van Deursen & van Dijk (2019) warn that inequality persists in the quality of equipment and connection even when access seems resolved, so that the contextual feasibility of the model responds to this twofold demand without waiting for the connection to improve before starting to teach.

Likewise, the model engages with TPACK by preserving the principle of articulation among content, pedagogy and technology that Mishra & Koehler (2006) formulated and that Koehler & Mishra (2009) refined by emphasizing that teacher knowledge is always exercised in a particular context. In this regard, Bueno et al. (2023) support this reading by arguing that TPACK should be extended toward the conditions surrounding practice, and the GATIC R Model makes this extension explicit by incorporating rural feasibility as a design criterion, whereby the original structure of the model is preserved and situated in a specific territory.

Finally, teacher training appears as a condition for the model to be sustained, since Alférez-Pastor et al. (2023) identified in their systematic review that future primary school teachers need specific training in digital competences, and Díaz-Burgos et al. (2024) showed that interventions to optimize this competence depend on psychological and educational factors that changed before and after the COVID-19 lockdown. In the same vein, Mella-Norambuena et al. (2024) note the lack of models that explain the pedagogical organization of the use of these platforms, a gap to which the present study responds with a situated proposal that, given its projective scope, cannot yet claim effects on learning.

CONCLUSIONS

The objective of modeling a management system for teaching and learning Technology and Informatics through Moodle was achieved with the formulation of the GATIC R Model, built from the diagnosis of fifth-grade students at the Institución Educativa Miguel Vicente Garrido Ortiz in Arboletes and rated by two experts at 114 out of 120 points. In light of the above, the postulates of sociocultural constructivism, connectivism and TPACK made it possible to establish that Moodle should function as the support of a learning architecture and not as a repository of resources independent of pedagogical decisions.

The results show that the technological competence of these students is uneven across its components, with a favorable attitude, functional use that depends on clear instructions and

conceptual mastery that needs strengthening in hardware, software, ICT and educational platforms, all in a school with few devices, an irregular connection and no organized digital resources. This indicates that the design of any digital proposal for rural primary education should start from a diagnosis of each dimension and of the setting before selecting the tools.

With regard to relevance, the expert assessment placed the pedagogical dimension at 3.9, the contextual dimension at 3.8 and the technological dimension at 3.7, and concentrated the adjustments on the clarity of the instructions, the file size of audiovisual resources and alternatives for low connectivity, without questioning the structure of the system. Consequently, it remains pending, as a declared limitation and as a challenge for future research, to implement the system over an academic period long enough to measure its effects on technological competences, to study its usability with students and teachers, and to examine its adaptation in other rural schools in the Urabá region of Antioquia with similar conditions.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest with any individuals or institutions related to this research.

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