https://doi.org/10.17163/soph.n38.2025.03

Inductive Methodologies in Education, Supported by the Integration of Technology

Metodologías inductivas en la educación, apoyadas por la integración de la tecnología

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Suggested citation: Collazo Fuentes, Magda, Veytia Bucheli, María Guadalupe & Rivera Alejo, Francisco Javier (2025). Inductive methodologies in education, supported by the integration of technology. *Sophia, Philosophy of Education Collection*, (38), pp. 103-129.

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Abstract

This paper analyzes the translation and validation of the instrument developed by Flores and Adlaon (2022) to apply the inductive method with the SAMR model in Spanish-speaking educational contexts. The justification for the topic lies in the need to adapt effective pedagogical tools to the Spanish language to facilitate their use in teaching and learning with technology. The main objectives are to translate the instrument and to carry out its semantic validation, through the judgment of experts in the educational and technological fields. The methodology included the translation of the instrument "Extent of ICT Integration in Science Based on SAMR Model" into Spanish, followed by its validation. The 11 experts evaluated the relevance and clarity of the items using a Likert scale from 0 to 5. The content validity was calculated with the Aiken V methodology, obtaining a coefficient of 0.8163, which indicates a good validity index, the Cronbach's Alpha value was 0.9682. The results showed that although most of the items were well rated, some required reformulation to improve their clarity, relevance and comprehension in the Spanish translation. The instrument proved to be adequate for evaluating the degree of integration of ICT in education, facilitating its application in Spanish-speaking contexts and promoting the adoption of inductive methodologies supported by educational technologies.

Keywords

Integration, Inductive Method, SAMR Model, Technology, Innovation, Pedagogy.

Resumen

El presente trabajo analiza la traducción y validación del instrumento desarrollado por Flores y Adlaon (2022) para aplicar el método inductivo con el modelo SAMR en contextos educativos hispanohablantes. La justificación del tema radica en la necesidad de adaptar herramientas pedagógicas efectivas al idioma español para facilitar su uso en la enseñanza-aprendizaje con tecnología. Los objetivos principales fueron traducir el instrumento y por medio del juicio de expertos en el área educativa y tecnológica, realizar su validación semántica. La metodología incluyó la traducción del instrumento Extent of ICT Integration in Science Based on SAMR Model al español, seguido de su validación. Los 11 expertos evaluaron la pertinencia y claridad de los ítems utilizando una escala Likert de 0 a 5. La validez de contenido se calculó con la metodología de la V de Aiken, obteniendo un coeficiente de 0,8163, lo que indica un índice de validez bueno, el valor alfa de Cronbach fue de 0,9682. Los resultados mostraron que, aunque la mayoría de los ítems fueron bien valorados, algunos requirieron reformulación para mejorar su claridad, pertinencia y comprensión en la traducción al idioma español. El instrumento demostró ser adecuado para evaluar el grado de integración de las TIC en la educación, facilitando su aplicación en contextos hispanohablantes y promoviendo la adopción de metodologías inductivas apoyadas por tecnologías educativas.

Palabras clave

Integración, método inductivo, modelo SAMR, tecnología, innovación, pedagogía.

Introduction

This article deals with the adaptation and validation of an evaluation instrument developed by Flores and Adlaon (2022), originally designed in English, to measure the level of integration of information and communication technologies (ICT) in scientific education, based on the SAMR model. This model is essential to guide teachers in the effective use of ICT,

Print ISSN:1390-3861 / Electronic ISSN: 1390-8626, pp. 103-129.

however, the absence of validated instruments in Spanish represents a challenge for its implementation in Spanish-speaking countries.

The objective of the study is to offer a translated and validated version of the instrument, capable of evaluating the integration of ICT in Spanish-speaking educational contexts. The problem lies in the lack of culturally and linguistically adapted tools to measure this aspect. It is proposed that the translated version will retain the validity and reliability of the original instrument, allowing its application with the same quality standards.

The relevance of the topic lies in the strategic role that ICTs play in 21st century education. Its integration not only complements traditional teaching methods, but deeply transforms the way knowledge is built and applied, potentially improving learning outcomes in an increasingly digitized global context.

The methodology used in this study included the translation of the original instrument and its validation by a panel of 11 experts. To analyze the content validity, the Aiken V index was used. The article is organized into five main sections: introduction, methodology, analysis of results, discussion and conclusions, followed by recommendations for future research.

The validation of instruments in the Hispanic-American context is essential to ensure that the tools used in research and educational practices are culturally and linguistically relevant. Often, the original instruments are developed in Anglo-Saxon contexts, which can lead to difficulties of interpretation and application in Spanish-speaking environments. Validating tools such as those that evaluate the integration of ICT under the SAMR model, allows educators and administrators to accurately measure the impact of technology on education. This is key to promoting active methodologies, improving learning outcomes and meeting the needs of students in an increasingly digitized world.

Ethical and pedagogical reflection on the integration of ICT in education

The use of technology in the scenarios of current society invites reflection on its integration. It is important to emphasize that technology and its use do not have defined qualities (Aguilar Gordón, 2011), i.e., they are not considered good or bad, on the contrary, their effectiveness depends on the way in which people use them and integrate them into their context. Therefore, what determines them is the ethical evaluation and the quality of judgment that is applied in order to satisfy the demands of current education.

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Whenever a technology emerges, it is presented as something new and advanced for its time. It is identified by the improvement it brings to traditional ways of doing things. However, its relevance and usefulness are temporary, hence the importance of basing its use and appropriation on pedagogical, cognitive and valuation models to understand its integration and level of appropriation that allow its constant improvement and integration especially in the educational field (Aguilar Gordón, 2011). Hence the importance of generating integration and application models that allow the development of learning based on active methodologies and deep learning, along with technological development.

The inductive method and its integration mediated by ICT in educational processes

The inductive method is defined as a teaching approach that promotes learning through observation and direct experience (Gagné, 2012), which allows students to develop knowledge from specific examples and lead them towards generalizations and principles; it fosters discovery, exploration and understanding of the world through observation and experimentation.

A fundamental component of the scientific approach is the inductive method (Palmett, 2020), since it follows stages that structure the research process until reaching the conclusions of the study. These stages include observation, data collection, verification, which allows to rigorously consolidate the findings obtained. By working from an inductive methodology, students are actively involved in the practical application of knowledge, before receiving formal explanations (Prieto *et al*., 2014). So, there are specific situations where they must find an explanation for themselves, a solution or an answer, which allows them to investigate and discover principles, theories, laws.

This approach aims to achieve a deep, connected and applied understanding of knowledge, in addition to generating a motivation to a greater number of students to actively engage and devote more time and effort to their learning, facilitating meaningful experiences. More durable learning is promoted, in which students will value and carry out knowledge transfers to future situations.

Inductive teaching and learning, according to Prince and Felder (2013), focus on active methodologies such as case studies, inquiry, problem-based learning, case-based learning, and project-based learning. These strategies are often more effective than traditional deductive methods in achieving expected learning outcomes.

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In the digital age, ICT has modified the application of the inductive method, by facilitating access to digital educational resources and interactive tools (Gesto, 2020). Online platforms allow students to explore and collect data efficiently, as well as engage collectively to foster peer discussion and build knowledge.

The pedagogical integration of ICT

The integration of ICTs is required to support the construction of knowledge, both individually and collaboratively, since nowadays not only content is learned by listening to a class, but also with the incorporation of different digital tools to move from lower-order thinking to higher-order thinking.

Technology for decades has been linked to different didactic strategies implemented, both in virtual classrooms and in classrooms in person. They are a set of tools that enable the acquisition, production, storage, treatment, communication, records and representation of information in various formats, useful in the training processes, both for the student and the teacher. Morales Urrutia *et al*. (2021) point out that it is necessary to link the integration of technologies to the training processes through the use of pedagogical models, such as Bloom's taxonomy, considered a tool to structure and understand learning, since it allows a student to go through each of the levels until reaching the maximum understanding of the new knowledge and put into practice his creative capacity.

Methodologies for the integration of technology in learning

Cruz Meza *et al*. (2023) generate a methodology for evaluation using SAMR methods, the "pedagogical wheel", the TPACK model and the John Biggs taxonomy, to reinforce teaching strategies and promote metacognition. Its proposal supports the importance of creating methodological processes that involve the setting of objectives, the design of activities and the choice of appropriate technological tools. As a result, they note that as taxonomic levels are promoted, the integration of technology reinforces higher-order thinking in the student.

Within this context, the integration of pedagogical approaches such as the inductive method, combined with technological tools and innovative models such as Allan Carrington's pedagogical wheel (2016), has shown a potential to enrich the educational experience, focusing on pedagogy instead of technological applications. This graphical tool faci-

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litates the integration of technology with the teaching-learning process and its design consists of several axes:

- Central axis representing the six cognitive levels of Bloom's taxonomy.
- Axis with four degrees of technological integration according to the SAMR model.
- Outer axis containing examples of technological tools and applications that can be used at each cognitive and technological integration level.

Each section of the wheel interconnects with the other sections, confirming that learning is not linear, but is in a process of evolution.

The foundation of Carrington's pedagogical wheel (2016), integrates two theoretical frameworks (Bloom taxonomy and SAMR model) in a visual representation that simplifies the combination of tools and technological strategies appropriate for each level of cognitive ability and technological integration. For Bloom's taxonomy (Campos, 2021), ascending from the basic to the most complex level is understood as inductive knowledge and is the starting point for incorporating technology into learning procedures.

The SAMR model, developed by Puentedura in 2014, consists of four levels of application, which are associated with Bloom's taxonomy: remember, understand, apply, associated with the levels of substitution and increase of the SAMR model, while the levels of modification and redefinition are associated with the levels of analysis, evaluation and creation of Bloom. The model is the guide for choosing activities to be used within a learning process that includes technology. The wheel of pedagogy is the element that helps to choose digital tools that can be used to develop the activities and take the student through each of the taxonomic levels to achieve metacognitive learning.

Therefore, it helps educators to select applications and technological resources that can be used to support different levels of cognitive skills ranging from memory and understanding, to creation and evaluation; it organizes technological applications around educational actions that support each level of Bloom's taxonomy (Carrington, 2016), fostering a clear and accessible framework for implementing technologies in the classroom in an effective and coherent way.

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The integration of the inductive method, the pedagogical wheel and ICT

This integration can transform the learning experience by providing students with opportunities to actively explore, experiment and build knowledge. The main contributions of this combination are highlighted below, accompanied by critical analyzes of its impact:

- *Observation and active exploration:* with the support of the pedagogical wheel, students can access applications and tools that facilitate the observation of phenomena and the direct collection of data (McKnight *et al*., 2016). For example, augmented reality applications allow to explore scientific concepts in a tangible and interactive way. This not only simplifies the understanding of complex topics, but also encourages active and autonomous learning, pillars of the inductive approach. The use of tools such as augmented reality generates a significant impact by transforming abstract concepts into concrete experiences, which strengthens the interest and motivation of students.
- *Guided discovery and constructivist learning:* the inductive method stimulates constructivist learning, where students build their knowledge through experience and reflection. The pedagogical wheel offers technological resources that enable guided discovery, such as virtual experiments and interactive simulations, that help students develop a deep and meaningful understanding of concepts (Johnson *et al*., 2016). This stage fosters critical thinking and problem-solving ability by allowing students to become protagonists in their own learning.
- *Reflection and generalization:* the technological tools integrated in the pedagogical wheel allow students to reflect on their experiences and generalize the acquired knowledge. Applications such as blogs and digital portfolios make it easier for them to document and analyze their learning, promoting the transition from specific experiences to general principles (Carrington, 2016). Reflection is a crucial component in meaningful learning, as it allows students to consolidate what they have learned and connect it to broader contexts.
- *Creation and evaluation:* In the final phase of inductive learning, students can employ technological tools to design projects and evaluate their achievements. The pedagogical wheel includes applications for the creation of videos, presentations and other materials,

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which allows to synthesize and share their discoveries in a creative and collaborative way (Carrington, 2016). This not only reinforces learning, but also drives the identification of achievements and areas for improvement in the training process. The creation allows students to develop key competencies such as communication, creativity and teamwork. In addition, the evaluation process encourages self-reflection and continuous improvement.

The integration of the inductive method, the pedagogical wheel and ICTs promotes dynamic, reflective and oriented learning in the development of essential competences for 21st century education. However, its success requires an intentional pedagogical design, appropriate teacher training and a balanced approach that considers both the opportunities and the challenges of these innovations.

The union of the above elements encourages active and autonomous learning, allowing students to discover and build knowledge from concrete and real experiences. By incorporating technology, opportunities to perform simulations, access global resources, and collaborate in virtual learning environments are diversified, enriching the induction process. This combination not only improves understanding and retention of knowledge, it also develops critical skills for the 21st century such as problem solving, critical thinking, and the ability to adapt to information and communication technologies.

Benefits of the educational wheel

The application of the inductive method, supported by the pedagogical wheel and technology, offers a variety of contributions in the educational field. These are reflected in the improvement of the learning experience and the integral development of the students. The main benefits and critical analysis are highlighted below:

- *Fostering curiosity and creativity:* the inductive approach stimulates students' innate creativity by offering them opportunities to explore and discover concepts for themselves. This is enhanced by technological tools, which provide new forms of interaction and experimentation, such as virtual simulations, augmented reality applications and digital creation spaces (Roblyer & Doering, 2013). Curiosity and creativity are fundamental to deep learning, as they motivate students to actively participate in the educational process. Success in this regard, however, de-

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pends on the right selection of technological tools and a pedagogical design that fosters a balance between creative freedom and clear educational goals.

- *21st century skills development:* the combination of inductive method, pedagogical wheel and ICT facilitates the development of key competences such as critical thinking, problem solving and digital literacy. These skills are essential in the contemporary world, where students must adapt to changing environments and solve problems in innovative ways (Johnson *et al*., 2016). Such competencies not only prepare students to face job challenges, but also enable them to become responsible and proactive citizens. However, 21st century skills development requires an intentional integration of activities that promote the analysis, collaboration and reflective use of technology, avoiding the superficial or exclusively technical use of tools.
- *Personalization of learning:* technology allows learning to be personalized in an inductive environment, offering students the possibility to advance at their own pace and focus on their specific interests and needs. This is especially relevant in a student-centered approach, where autonomy and meaningful learning are priorities (McKnight *et al*., 2016). Personalization of learning has the potential to increase students' motivation and commitment by connecting educational content with their personal interests. This poses logistical and pedagogical challenges, such as the need for an adequate technological infrastructure and the ability of the teacher to design differentiated strategies that maximize the potential of each student without generating inequalities.

The integration of the inductive method, the pedagogical wheel and technology offers a powerful framework for transforming education. However, its successful implementation depends on careful pedagogical planning, teacher training and strategic selection of technological tools that enhance learning objectives. The inductive method, in combination with Allan Carrington's pedagogical wheel and the use of ICT, represents an innovative approach to teaching-learning in the 21st century, as it allows facing the challenges and opportunities of an increasingly complex and digital world.

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Research on the educational wheel and the SAMR model

There are different investigations that address the use of the pedagogical wheel, among which Cepeda Moya and Argudo Serrano (2022), who recover the perceptions of both teachers and Ecuadorian students about the SAMR model through an interview, where results emphasize the beneficial uses of technology for meaningful learning.

The use of the pedagogical wheel is also linked to the use of artificial intelligence (AI) tools in the research of Jiménez García *et al.* (2024), who carried out a systematic mapping of the literature and highlight the incorporation of AI gradually, in addition to including a metacognitive level of reflection where the importance of ethics and academic integrity is highlighted.

Flores and Adlaon (2022), carry out a study that addresses the integration of teachers' ICT from the SAMR model of Puentedura (2014). Flores and Adlaon (2022) produce a questionnaire validated by experts and subjected to statistical tests. The study concludes that the incorporation of ICT improves student learning, however, the instrument is in English. Therefore, the objective of this article is to translate and validate the instrument Degree of Integration of ICT according to the SAMR model, through judges, to be used by teachers from Latin America and from the results obtained, generate practices oriented to continuous improvement.

Materials and methods

In this research article, a quantitative methodology was adopted, focused on the validation of the evaluation instrument of the SAMR model adapted to Spanish. The research is framed in a non-experimental design, using as main techniques the translation and validation of the instrument by applying the Aiken V to measure the validity of content. The data collection was carried out with the collaboration of 11 experts in the field of education and ICT, who evaluated the clarity and relevance of each item.

From a post-positivist epistemic position, this research ensures the objectivity and reliability of the results, proposing that reality can be known through rigorous methods that allow corroborating or falsifying hypotheses. The study is based on the idea that educational phenomena, in this case, the integration of ICT, can be measured and understood objectively, which allows offering adequate and validated tools for Spanish-speaking educational contexts. Thus, an empirical approach is combined

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with the need to culturally contextualize the instrument to ensure its applicability and relevance.

The consistency of an instrument in a research process involves judging components that have to do with the validity of the content, criterion and construct, each of them alludes to a different aspect and the use of one or the other will depend on the type of evidence that is intended to be used (Robles Pastor, 2018). In this sense, content validation, according to Escobar Pérez and Cuervo Martínez (2008), applies to different situations, especially when it comes to the design of a test or the assessment of an instrument created for subjects from different regions adapted through semantic equivalence or translation.

The conceptual essence of the term "content validity" involves assessing the extent to which the items of an instrument are relevant and represent the purpose of its construction. When these have been adapted or translated into a different language, it is very common for the interpretation or approach in a new language to generate interpretative or cultural gaps, which require the judgment of experts. They are the ones who, due to the experience in the area, determine which items should be eliminated, modified, reconstructed or even add new terms or concepts that are considered relevant to replace the idiomatic expressions and that the instrument gains more relevance and representativeness (Escobar Pérez & Cuervo Martínez, 2008).

Previous studies (Guerrero Fernández *et al*., 2022) report the creation and validation of an instrument to measure the different dimensions and items with the aim of analyzing both clarity and relevance. The results show how the process of evaluation by judges allowed to evaluate an instrument to detect the degree of environmental literacy of future teachers of early childhood and primary education through the Aiken V.

In addition, Alemán Saravia *et al*. (2023, p. 463) identify the imperative need for assessment tools within the Latin American population to measure the degree of integration of technology, pedagogy and content as base elements for teaching performance, so they developed a translation, cultural adaptation and validation of the TPACK-21 questionnaire. The results allowed validating the instrument to be applied reliably to primary and secondary teachers in Peru.

For the present research, the validation was carried out for the Spanish translation of the Extent of ICT Integration in Science Based on SAMR Model, which was divided into the four original sections that allow to analyze the level of ICT integration: substitution, argumentation, modification and redefinition (table 1). In order to improve reliability, it

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was decided to eliminate the response option with a value of 0, taking it as the minimum value or one that reflected total disagreement with the proposal presented and was replaced for analysis by the value of 1. However, in the presentation to the judges, the scale was developed with a range of responses from 0 to 5 to validate the basic criteria of: relevance (correspondence of the content of the item and the dimension for which it is to be used) and clarity (degree to which the item is written clearly and precisely, facilitating understanding for respondents).

Table 1
Dimensions and descriptors of the instrument

Dimension	Item	Pedagogical wheel	SAMR. Model Application Criteria
Replacement	1–10	Remember, learn, apply technology	Replace without functional change
Increase	1–10	Remember, learn, apply technology	Replace with functional enhancement
Modification	1–10	Analyze, evaluate, create	Significant task redesign
Redefinition	1–10	Analyze, evaluate, create	New tasks that were previously inconceivable

Formation of the expert group to initiate validation

The group of judges consisted of 11 researchers from various universities. It was determined that they had the degree of doctor preferably in the lines of education and ICT, as well as the performance within the teaching at the university level. Likewise, it was determined to consider those who work with the use of technology within the classroom due to their educational profile.

The Spanish version of the instrument was sent to the judges and they were asked to make a judgment by means of a Likert scale where the value of 0 corresponded to the minimum relevance and/or clarity in the item, and 5 corresponded to the maximum value of these criteria.

Subsequently, the conformation of the database of the results obtained was made. For its validation, the "content validity coefficient" was obtained through the methodology of Hernández Nieto (2002), with a result of 0.8163. This places it as a good instrument within the evaluative scale. Those items that scored less than 0.80 and matched the suggested

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changes were modified as observed by the judges. Otherwise, the modification was made to make its translation clear and relevant. The changes are shown in Table 2, within the qualitative assessment of the validity of the instrument.

For the statistical valuation of the instrument, the responses of the 11 experts were collected with the valuation of the instrument of each of the items. The analysis was carried out using a database developed in Excel and Aiken's formula V was applied. In general, the final score of the four dimensions is observed in Table 3.

Analysis and results

Table 2 shows the results of three of the dimensions that make up the instrument. In the *substitution* dimension, item 6 has a score of 0.752, which is why it is reformulated to integrate the comments and observations issued by the judges. However, reagents 4, 5 and 9 meet the construct value greater than 0.75, these are modified according to the observations of the experts. For the *argumentation* category of the 5 redesigned items, the 9 get a score of 0.743; i.e., below the minimum construct validity level, so it is adapted for greater understanding. For the *modification* dimension none of the items was below the value; however, items 3, 4, 7 and 8 are reformulated to address the points in the evaluation process and achieve a better interpretation in their translation. In the *redefinition* dimension only item 9 was below the construct value, with a score of 0.685, which implied its restructuring.

Table 2
Results of construct value

Dimension	Item No	Construct Value
Replacement	6	0.752
Argument	9	0.743
Redefinition	9	0.685

Qualitative validity assessment

The reformulated items of the replacement dimension were 4, 5, 6 and 9; once evaluated by the expert these are modified for a better unders-

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tanding. In the case of item 4 used to evaluate the creation of mental maps using Microsoft Word, it is suggested to add specialized apps such as: Office, Libre office, Google Slides, Smart Office, Adobe Reader, Polarice office, among others. For submitting projects in the case of item 5, it was suggested that it should not be limited to email or Facebook, but that these digital platforms should be integrated as an element that improves communication between participants.

Item 6 measures the tabulation of data using electronic counting sheets when the experiment is performed, and it is reformulated for better interpretation, remaining as follows: during the performance of experiments the data are recorded in electronic spreadsheets, allowing an organized handling of information and a more accurate analysis of it. Finally, for this dimension, item 9, which measures the use of digital images to make a virtual visit, is reformulated considering the importance of pointing to copyright or author data.

In the dimension of argumentation, items 4, 7, 8, 9 and 10 are suitable for the use of digital tools that integrate animations and locutions (item 4); its reformulation focuses on narrative for better understanding. Item 7 in its translated version is not clear, so it is drafted in a more detailed way. Item 8 measures the use during the class of videos of other speakers related to the lesson. The results obtained are modified to specifically indicate the incorporation of videos made by experts and external speakers. The integration of video clips for a virtual visit (item 9) is redefined by adding augmented reality applications to perform virtual visits and strengthen knowledge. Finally, item 10 is reformulated as a result of the evaluation, adding items such as the Google Sheets spreadsheet.

For the *modification* dimension, the items reformulated according to the results obtained were 3, 4, 7 and 8. In this category, the judges considered the importance of digital tools as support for the creation of collaborative and interactive processes. In this sense, elements such as the e-portfolio are integrated to document and generate evidence of work using web platforms such as: Google Sites blogs, OneDrive, Dropbox in item 3.

Item 4 is modified since the judges valued the importance of improving its semantic writing, remaining as follows: synchronous discussions are implemented through chats and/or group blogs to create conceptual or mental maps in a team. The translated version was not clear about collaborative work in a synchronous way and the potential that this type of activities can generate in the class.

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As for the translation of item 7 that points out: the annotation of the e-books, e-handouts or e-notes of class (Notes App, Google Doc or Microsoft Word), it is done in a collaborative way. Semantic elements are added after the assessment, leaving a more descriptive version that emphasizes the registration of the class work in a collaborative way. Finally, the translated wording of item 8, contrasted with the version modified at the suggestion of the experts, focuses on the use of more common words in the Latin American continent, for example, the change from "student" to "student" is observed.

The dimension of redefinition had to be modified in items 1, 7 and 9. The first two, despite obtaining a score greater than 0.75 in the construct value, integrate in its translated version the aspects suggested by the judges for a better understanding in its wording, for example, the active collaboration in Google Forms, Kahoot, Mentimeter, etc., is implemented in the realization of questionnaires that serve as review material (item 1), is modified by: *it implements* the active collaboration *through the use of interactive applications such as* Google Forms, Kahoot, Mentimenter among others, *to generate* questionnaires that serve as review material.

Regarding items 7 and 9, the semantic changes seek to integrate at the suggestion of experts, aspects about the use of collaborative work and virtual reality to enrich learning experiences. For example, item 9 is modified as follows: virtual tours are implemented through the use of virtual reality to generate immersive learning experiences.

Other changes suggested by the judges related to the incorporation of free *software*, the integration of AI, as well as the description of the acronyms LMS (*learning management system*) and MS (Microsoft). On the other hand, it was requested to translate the word *online* as well as to replace Microsoft Word with "word processor" in those items that mention the use of the program for the conduction of some activity related to the elaboration of text documents. It was suggested to make clarifications about the concept of "virtual visit", so we choose to integrate "immersive spaces" or "virtual reality" to focus attention on the generation of educational experiences where technology can generate experiential learning.

Statistical validity assessment

Cronbach's alpha value was 0.9682, which reaffirms the validity of the Extent of ICT Integration in Science Based on SMAR Model by Flores and Adlaon (2022), in its Spanish translation. Aiken's V was applied to each of

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the dimensions, which quantifies the relevance of the items in relation to the validity of content from the evaluations of the judges (Aiken, 1980).

Table 3
Cronbach alpha value of the instrument

K	80
Item Variance	0.08
Si2	92.00
St2	2099.54
α	0.9682843737

The questionnaire with 80 reagents has a low average variance (0.08), suggesting that the responses are homogeneous. The total test variance is 2099.54 and the average variance is 92.00. The Cronbach alpha value of 0.968 indicates excellent internal consistency, which means that the reagents are highly reliable and consistently measure the construct to be evaluated. In summary, these data suggest that the questionnaire is very reliable and suitable for research or evaluation.

Table 4
Cronbach alpha value of "relevance"

α (alpha)	0.8958762405
K (number of items)	40
Vi (variance per item)	45.30578512
Vt (total item sum variance)	358.09

The questionnaire with 40 reagents presents a relatively high average variance (45.31), indicating that there is considerable variability in individual responses. The total variance of the test is 358.09, suggesting that the total scores obtained by the individuals in the test also show good dispersion. The Cronbach alpha value of 0.896 indicates a high internal consistency. In summary, these data suggest that the questionnaire is reliable and suitable for research or evaluation as results are consistent and responses vary significantly among participants, providing a good basis for interpretation.

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Table 5
Cronbach alpha value of "clarity"

α (alpha)	0.964993639
K (number of items)	40
Vi (variance per item)	46.52892562
Vt (total item sum variance)	786.8760331

The questionnaire with 40 reagents presents an average variance of 46.53, indicating considerable variability in individual responses. The total variance of the test is 786.88, suggesting that the total scores obtained by the individuals show a wide dispersion, reflecting a good discrimination between different levels of skill or knowledge among the participants.

The Cronbach alpha value of 0.965 indicates excellent internal consistency, meaning that the items are very well correlated and that the test consistently measures the construct to be evaluated. In summary, these data suggest that the questionnaire is highly reliable and suitable for research or evaluation, as it provides consistent and valid results with good discrimination between participants.

Table 6
Aiken V values of the dimension "substitution" by reagent

	Item	Criterion	Average	D. e. p.	V of Aiken	Bottom Lim	Top Lim
Replacement	Item 5	Clarity	4.5	1,157	0.041	0.012	0.159
		Relevance	4.3	1,213	0.025	0.005	0.132
	Item 6	Clarity	3.9	1,443	–0.008	0.001	0.070
		Relevance	4.3	1,355	0.025	0.005	0.132

For the substitution dimension in reagent 6, an Aiken value of –0.008 was obtained for the category of clarity, which corresponds to the construct validity and the modification suggested by the judges. In this same dimension, reagent 5 obtains a value of 0.025, coinciding with its restructuring according to internal validity.

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Table 7
Aiken V values of the dimension "argumentation" by reagent

	Item	Criterion	Average	D. e. p.	V of Aiken	Inferior Lim	Superior Lim
Argument	Item 14	Clarity	4.5	1,157	0.050	0.016	0.171
		Relevance	4.2	1,527	0.017	0.003	0.118
	Item 17	Clarity	4.4	1,226	0.033	0.008	0.146
		Relevance	4.1	1,505	0.008	0.001	0.103
	Item 18	Clarity	4.5	1,157	0.050	0.016	0.171
		Relevance	4.2	1,527	0.017	0.003	0.118
	Item 19	Clarity	4.4	1,651	0.033	0.008	0.146
		Relevance	4.0	1,651	0,000	0,000	0.088

For the dimension of argumentation, items 14, 17, 18 and 19 according to the above table have a coincidence with construct validity and have been modified in the wording for a better understanding in its Spanish translation. The values obtained in the validity of the construct agree with Aiken's score and have been modified for its better understanding.

Table 8
Aiken V values of the dimension "modification" by reagent

	Item	Criterion	Average	D. e. p.	V of Aiken	Inferior Lim	Superior Lim
Modification	Item 27	Clarity	4.2	1,266	0.017	0.003	0.118
		Relevance	4.5	0.782	0.050	0.016	0.171
	Item 28	Clarity	4.5	1,157	0.050	0.016	0.171
		Relevance	4.2	1,527	0.017	0.003	0.118

For this dimension, reagents 27 and 28 obtain a coincidence in Aiken's assessment and in relation to construct validity according to Hernández Nieto (2002), so they are modified in their wording. Although reagents 23 and 24 are not at a high level of coincidence, these were modified at the suggestion of the judges.

Print ISSN:1390-3861 / Electronic ISSN: 1390-8626, pp. 103-129.

Table 9 Aiken V values of the dimension "redefinition" by reagent

	Item	Criterion	Average	D. e. p.	V of Aiken	Inferior Lim	Superior Lim
Redefinition	Item 31	Clarity	4.5	0.988	0.041	0.012	0.159
		Relevance	4.5	1,157	0.041	0.012	0.159
	Item 37	Clarity	3.7	1,150	–0.025	NULL	NULL
		Relevance	3.9	1,781	–0.008	0.001	0.070
	Item 38	Clarity	2.8	1.992	–0.107	NULL	NULL
		Relevance	3.2	1.992	–0.074	NULL	NULL
	Item 39	Clarity	4.6	0.881	0.058	0.020	0.184
		Relevance	4.7	0.862	0.066	0.024	0.196

The redefinition dimension obtained in items 31, 37, 38 and 39 a score of 0.041, –0.025, –0.107 and –0.074, which coincides with the validity of the construct and suggestions for modification of the judges, so that their restructuring is carried out; they are modified and adapted for a better understanding in their translation into Spanish.

The instrument in its Spanish version

The objective of this work is to obtain a translated and validated version of the instrument created to assess the degree of integration of ICT in science according to the SAMR model (Flores & Adlaon, 2022). It is considered extremely necessary to present the translated and validated version of the instrument so that the population of researchers and university professors can apply it in Spanish-speaking research that aims to measure the level of use and appropriation of technology in the educational field.

Each of the dimensions modified according to the statistical and qualitative results obtained are presented below. The measurement scale for each of the parameters is from 1 to 4, where 1 expresses the option of "totally disagree", option 2 "disagree", the value of 3 describes the option of "agree" and 4 corresponds to "totally agree".

Replacement

1. Forms from Google, Kahoot, Mentimeter and other tools are used in formative and summative assessments.

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2. Images or mock-ups are used to make a visual presentation of the lessons.
3. Some word processor is used when preparing electronic portfolios
4. Conceptual or mental maps of the lessons are created using diverse software that replaces specialized apps such as: Office, Libreoffice, Google Slides, Smart Office, Adobe Reader, Polarice office, among others.
5. Projects are sent through digital platforms, such as email or Facebook Messenger. This replaces the physical delivery of documents allowing communication to be more efficient and faster.
6. During the conduction of experiments the data are recorded in electronic spreadsheets, allowing an organized handling of the information and a more precise analysis of it, thus replacing manual recording of information.
7. Evident-Notes (Notes App, Google Doc or word processors) are used for note-taking.
8. Pre-recorded lessons are used during the class.
9. Digital images are used without copyright or mentioning the author to know a place, space or community virtually.
10 Record sheets are used to record data collected in research studies.

Argument

1. Multimedia is integrated into Google Forms, Kahoot, Mentimeter, etc., to improve students' understanding of how to conduct formative and summative assessments.
2. The lesson features video clips to explain and support the visual presentation.
3. Use of Microsoft Word.
4. Conceptual or mental maps are created using digital tools that allow the inclusion of animations to make the lessons more dynamic and interactive.
5. Projects are uploaded and compiled directly into an online folder for centralized feedback and enhancements.
6. MS Excel or spreadsheet is used to present the data when the experiment is performed.
7. Electronic notes are enriched by integrating multimedia elements such as images, videos and other digital elements using applications such as: Notes App, Google Doc, or word processors to complement textual information.

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8. The class incorporates videos from experts and external speakers related to the topic to complement the content of the lesson.
9. Video clips or augmented reality applications are used to conduct virtual tours and reinforce knowledge.
10. Microsoft Excel or some other spreadsheet application such as Google Sheets is used to generate charts and present data from a research study.

Modification

1. Forms from Google, Kahoot, Mentimeter, etc., always show scores and comments after formative and summative evaluations.
2. Augmented reality or any live 3D enhancements are applied to improve the visuals of the lessons.
3. E-portfolios are created to document and generate evidence of work using web platforms such as: Google Sites blogs, OneDrive, Dropbox.
4. Synchronous discussions are implemented through chats and/or group blogs to create conceptual or mental maps in a team.
5. Projects are submitted using Google Classroom or another LMS for automated tracking.
6. The experiment class data is published on an online platform to view graphs and tables in real time.
7. The class work is recorded in a collaborative way using applications such as: Notes App, Google Doc or word processors, to generate e-books, e-handouts or e-notes.
8. Students are encouraged to be part of online courses related to the lesson to reinforce their learning.
9. Google Earth is used for a virtual tour.
10. The delivery of hyperlinked surveys to community members and the local population is used to collect data in a research study.

Redefinition

1. Active collaboration is implemented through interactive applications such as Google Forms, Kahoot, Mentimenter among others, to generate questionnaires that serve as review material.
2. Virtual reality is used for the immersive content of lessons.
3. Evidence portfolios are reviewed or evaluated by students on Google sites or on any blog site in the comments section.

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Print ISSN:1390-3861 / Electronic ISSN: 1390-8626, pp. 103-129.

4. The class collaboratively contributed to the concept or mind map for the entire lesson through an active online platform.
5. Projects are submitted via Google Classroom or other LMS and are reviewed or evaluated by students in the comments section.
6. The result of the experimentation is shared on-screen in the class for discussion.
7. The class actively collaborates in the generation of class notes and scores them on an online platform.
8. Students are encouraged to participate and comment in the contributions section of the massive open online courses (EdX, Coursera, Khan Academy, Canva).
9. Virtual tours are implemented through virtual reality to generate immersive learning experiences.
10. To collect data in a research study, online surveys are published to target a global audience.

Discussion

The validation of the instrument to evaluate the integration of ICT in scientific education, adapted to the Spanish-speaking context, has revealed significant findings that should be discussed in depth. First, the methodology used, which included the translation and validation of the instrument through an expert panel has proven effective in ensuring clarity and relevance of the reagents. The application of Aiken's V has allowed establishing the validity of the instrument's content, which is crucial for its use in specific educational contexts.

It is important to identify previous studies that have been carried out on the translation and adaptation of instruments oriented to the use of technologies. German Saravia *et al*. (2023) carried out the translation, adaptation and validation of Valtonen's "Questionnaire on technological, pedagogical and content knowledge for 21st century skills" (TPACK-21). The experience of Lobos *et al*. (2022) is also recovered, since they carried out the adaptation and validation of two questionnaires on the implementation of technology in university teaching; from the validation, the authors identify four factors different from the original proposal and make the appropriate adjustments. Likewise, Cabero Almenara and Palacios Rodríguez (2020) carry out the translation and adaptation of the DigCompuEdu Check In questionnaire, in order to improve the level of

Print ISSN:1390-3861 / Electronic ISSN: 1390-8626, pp. 103-129.

digital competence of teachers from the implementation of training and personalized plans.

The results obtained indicate that the integration of ICT in education is not only necessary, but can also be measured effectively using culturally adapted tools. This is especially relevant in a context where education is constantly evolving due to the rapid adoption of digital technologies. Discussion of the effectiveness of ICT in learning aligns with previous studies, suggesting that technology can transform the way knowledge is built and applied.

In this sense, the implementation of pedagogical models such as *e-learning, b-learning* and *mobile learning,* which have been favored by the integration of ICT, has been a focal point in the discussion. These models not only promote more active and collaborative learning, but also encourage students' participation in building their own knowledge, as well as the ability to collaborate online and generate content, such as mind maps and class notes, highlighting the importance of digital platforms in the educational process.

Finally, this study opens the door to future research that could explore the application of the instrument in different educational contexts and its impact on learning outcomes. Validation of culturally adapted assessment tools is essential to ensure that the specific needs of educators and students in the Spanish-speaking environment are addressed, thereby promoting more inclusive and effective education.

Conclusions

The use of ICT offers the possibility of incorporating new tools, resources, media and formats, which allow the application of didactic strategies in the construction of knowledge. The application of pedagogical models such as *e-learning, b-learning* or *mobile learning* is considered an innovation of modern learning, which encourages teachers to organize, design and create materials, becoming a mediator and connector of various forms of didactic accompaniment (Cobos *et al*., 2020).

This study has managed to translate and validate an instrument designed to evaluate the integration of ICT in scientific education, adapting it to the Spanish-speaking context. Through the collaboration of a panel of 11 experts, it has been confirmed that the Spanish version of the instrument maintains its validity and reliability. The results of the analysis of Aiken's V and Cronbach's alpha have shown a high agree-

Print ISSN:1390-3861 / Electronic ISSN: 1390-8626, pp. 103-129.

ment between the evaluators in terms of the clarity and relevance of the reagents, suggesting that the instrument is suitable for its application in educational practice.

Validation of this tool is crucial as it provides educators and administrators with an effective tool to measure the use and ownership of ICT in higher education. This improves pedagogical practices and encourages research in a field that is increasingly relevant in a digitized world. The adaptation and validation of assessment tools such as the one presented in this study are essential to ensure that educational methodologies are culturally relevant and linguistically appropriate, which not only benefits researchers and professors in Spanish-speaking countries but promotes a more inclusive and effective approach to the integration of ICT in education.

Future research could explore the application of the instrument in different contexts and educational levels and its impact on learning, as well as the need for continuous training for teachers in the use of ICT, ensuring that technological integration is carried out effectively and meaningfully.

These recommendations aim to strengthen research and educational practice, promoting a more effective and contextualized use of ICT in scientific teaching. It should not be forgotten that the teaching role in a training process involves the design of instruction and the development of content using technology. Valverde and Balladares (2017) point out that the role of students has to do with the interaction and communication that is given through ICT and their integration with the in-person or virtual educational environments, creating links, processes, and essential collaborations to build learning communities.

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Print ISSN:1390-3861 / Electronic ISSN: 1390-8626, pp. 103-129.

Declaration of Authorship - Taxonomy CRediT	
Authors	**Contributions**
Magda Collazo Fuentes **María Guadalupe Veytia Bucheli** **Francisco Javier Rivera Alejo**	• Conceptualization: Ideas for research, general objectives of research. • Data curation: Purge research data. • Formal analysis: Application of statistical techniques to analyze and synthesize studies. • Research: Conduct research and exploration processes. • Methodology: Methodology design. • Project Management: Responsibility for supervision, management, coordination and planning leadership. • Writing: Preparation, creation and presentation of the work.

Artificial Intelligence Use Statement
Magda Collazo Fuentes, María Guadalupe Veytia Bucheli and Francisco Javier Rivera Alejo, DECLARE that the elaboration of the article ***Inductive Methodologies in Education, supported by the integration of technology***, had the support of Artificial Intelligence (AI) to improve quality and to avoid the repetition of terms specifically detected on page 3 of the document.

Received on: July 22, 2024
Reviewed on: September 25, 2024
Approved on: November 22, 2024
Published on: January 15, 2025