Modelo de Referencia de Apropiación de Tecnologías Digitales para el Aprendizaje en Instituciones de Educación Superior

Reference Model of Appropriation of Digital Technologies for Learning in Higher Education Institutions

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Abstract. In the digital age, technology for learning has promoted a constant evolution in educational dynamics. This leads higher education institutions to rethink themselves with new styles or models to achieve the adoption and adaptation of technologies in new academic environments. However, very few frameworks for acquiring and deploying digital technologies for learning that integrate such technologies. This paper proposes a model to guide the appropriation of digital learning technologies in the Higher Education Institutions. To achieve it, initially, an exploration of the literature concerning the appropriation of digital technologies in the context of learning for higher education institutions was made, and then, data was collected that allowed us to understand the state of the appropriation of digital technologies for learning; Thus, a model with interrelated components for appropriate digital technologies for learning was designed. It included metrics that allow us to know the level of appropriation. Finally, the authors validated its relevance to digital technologies for learning projects among stakeholders through their strategic guidelines for appropriation in different academic contexts.

Keywords: digital technology adoption · appropriation learning technologies in higher education · digital technology adaptation

1 Introduction

Digital technologies are an essential and determining factor in the educational field. They make Higher Education Institutions (HEIs) assume challenges related to appropriating digital technologies for learning. These challenges dynamize the way knowledge is transmitted and how these technologies remain in constant evolution [1]. Technology appropriation models have historically focused on different business sectors such as the financial sector [2–4]. Currently, the transformative potential lies in using digital technologies, favoring new forms of learning [1]. It leads HEIs to rethink themselves from new models to achieve the adoption and adaptation of technologies in academic environments. However, this situation is carried out inconsistently due to the desynchronization of technology management processes, and very few frameworks focused on learning [1, 5]. This article proposes a model to guide HEIs in appropriating digital technologies for learning (DLT). To achieve this objective, we define the following phases:

In the first phase, we explored the literature. In the second phase, we collected data to understand the current status of HEIs in adopting and adapting digital technologies for learning. In the third phase, we designed the model for appropriating digital technologies for learning. We validated the proposed model through a case study in the fourth phase.

2 Methodology

This project has a descriptive research approach of a composite, qualitative, and quantitative nature. The qualitative approach will be carried out with a documentary analysis focused on evaluating components that occur in the appropriation of DLT for HEIs worldwide. The quantitative approach will be carried out using data collection through surveys and metrics. The above will be developed in phases as follows:

First phase. To understand the challenges and best practices that influence the appropriation of digital technologies in the learning context of HEIs, we explore the academic literature on HEIs. We collect all information through the information search log. We consulted databases such as Scopus, IEEE, Computers & Applied Sciences Complete, and SCIELO, finding types of sources such as articles, books, web pages, and conferences. Around 35 documents, with which we carried out a systematic, not in-depth, literature review. Notable findings such as the TOGAF in Architectural Development Methods (ADM) [8] influenced the proposed model on technological solutions, improvement opportunities, and process supervision through initiative reception forms and interdisciplinary groups. The proposed model was also influenced by frameworks such as COBIT in its Align, Plan, and Organize components [9–11]. The Project Management Institute (PMI), under its Project Management Fundamentals Guide (PMBOK) administered by the Project Management Office (PMO) [12–14], provides our model with the project management reference, technological resources and skills, facilitating the path towards the appropriation of DLT. Our model also includes the DigCompEdu framework [15, 16] digital resources area and teaching and learning area. We are considering the importance of knowing how to transfer the benefits of digital technologies for learning and developing digital skills in teachers.

Second phase. Two surveys will be developed: one aimed at employees with academic positions and the other at IT employees. According to [17], there are 56 accredited universities in Colombia, and 11 have their main headquarters in the city of Medellín. The surveys include variables related to DLT appropriation, which will guide understanding of the current adoption, adaptation, and perception of DLT use. The data collected will be analyzed and interpreted to provide a comprehensive view of the appropriation of digital technologies in the learning context.

Third phase. In this phase, the reference model for the appropriation of digital technologies for learning is defined, with its DLT adoption and DLT adaptation components and the ways of interaction between them.

Fourth phase. In this phase, we validate the proposed DLT reference model for IES through a case study. We chose an IES accredited by the Colombian Ministry of Education and based in the city of Medellín. This HEI has implanted digital technology and uses at least one related framework in phase one. Thanks to the information provided by the university and the survey carried out among the project members and beneficiaries, the metrics established in the proposed model can be evaluated.

The objective is to propose a reference model for appropriating technologies for learning in higher education institutions based on the knowledge acquired and the data collected.

3 Literature review

3.1 Theoretical framework

TAM and TAM2 models. The Technological Acceptance Model (TAM) proposes two components: Perceived usefulness is the intrinsic possibility of the user when using the system, detailing the increase in their professional performance, and perceived ease of use infers the minimum effort that the user makes in the system [18]. For its part, in [3] the TAM2 model incorporates additional theoretical constructions that cover social influence processes. Furthermore, it groups three elements: subjective norm, image, and voluntariness.

Carrol Technological Appropriation Model. In [4] he defines three levels: the user in his first encounter with the technology, where there are initial reflections without having the experience of prolonged use. The evaluation is carried out here by the user; Evaluate through use whether the user's attraction is felt or not. The user integrates the technology, appropriating it for daily use.

UTAUT and UTAUT2 models. The Unified Model of Acceptance and Use of Technology Theory (UTAUT) [19] contains four themes: effort expectation, social influence, facilitating conditions, and level expectation. In the [3] UTAUT2 model, three new issues are added: hedonic motivation, the associated cost, and the habit of using technology.

COBIT. It is a framework first published in 1996, Control Objectives for Information and Related Technologies (COBIT) [11]. Initially, it was for government and information technology management. It evolved, allowing small businesses to create an IT governance system. [9]. COBIT 2019 has more flexible and collaborative strategies that address emerging digital technologies aimed at governance, management, and implementation objectives [10].

TOGAF. The Open Group Architectural Framework (TOGAF) in [8] defines it as an architectural framework that allows data, applications, technological infrastructure, and business processes to fully align with digital technologies to achieve the organization's strategic objectives. TOGAF features four domains:

data, technology, applications, and business. Proposes an architecture development method (ADM) [8].

European Reference Framework for the Digital Competence of Educators. (DigCompEdu) In [15] they propose six areas with twenty-two components, focusing on teachers developing their digital competence based on policies aimed at adapting and implementing tools and training programs, including a common language that facilitates the exchange of better practices. In [15], the following levels are described: Novice, Explorer, Integrator, Expert, Leader, and Pioneer. These levels measure the advancement of teachers' digital competence according to the indicated area.

Project Management Institute (PMI). In [13, 14], they define it as an international non-profit organization for project managers that generates and oversees the guidance and documentation of the project management body of knowledge called PMBOK, which contains best practices, guidelines, processes, and standard terms for project management. In [12], they define the Project Office (PMO - Project Management Office) as an organizational entity whose objectives, processes, and functions manage projects based on the guidelines provided in the PMBOK. This literature review identifies factors that promote the reference model of appropriation of digital technologies for learning in HEIs.

3.2 State of the Art

The world is growing and advancing at a dizzying rate in digital technologies, so much so that sometimes it is not possible to distinguish its purpose, which is why it is essential to frame the types of DLT into three:

Digital Technology for Learning Management. Helps manage resources, activities, courses, teachers, and students in a virtual space simultaneously. Learning Management Systems (LMS) are aimed at educational management to support administrative processes and optimize student learning [21]. In [6], they infer that the LMS is designed to support the various learning functions, facilitating online collaboration between students, teachers, and administrators. In [22, 23] they highlight the flexibility of accessibility and functionality and the loading of content and presentation in the design to support third-party plugins. In [24, 25], they state that it aims to improve educators' capacity, providing methods, strategies, and techniques for learning.

Digital Assistive Technology or Learning Support. It aims to optimize the moment of learning, improve the conditions in which academic interaction occurs, and help to maintain motivation, concentration, and attention [7, 26]. They seek to integrate tools to support learning processes facing academic challenges, supporting the accelerated changes of technology [27].

Emerging Digital Technologies for Learning. They are new technological trends with a high potential to alter academic learning. In [28], they explain that they are essential to take the step from traditional to intelligent education. In [29], they attest to the important impact they have had on learning, so much so that Machine Learning (ML) and BlockChain (BC) have played a leading role in the educational process. In [30, 31], a model is proposed that combines two Emerging Technologies such as ML and BC. The BC securely stores student data, and the ML, with the data stored in BC Pressure, predicts students' future job roles after graduation. This will provide HEIs and employers with a platform to verify the integrity of academic records. According to [32], these reach a high level of adoption in a range of 2 to 10 years. In [33], they propose Learning Experience Platforms (LXPs) that use Artificial Intelligence (AI) and ML to track and analyze data and provide users with an intuitive experience.

3.3 Analysis of the state of the art

To understand the challenges and best practices that influence the appropriation of digital technologies in the learning context of HEIs, we consulted databases such as Scopus, IEEE, Computers & Applied Sciences Complete, and SCIELO, finding types of sources such as articles, books, web pages, and conferences. Around 35 documents, with which we carry out the analysis of the state of the art from two points of view:

Review of literature similar to the proposal presented in this document. A literature review is similar to the proposal presented in this document. Different authors identified the types of digital learning technology, according to section 3.2, which reveals that LMS technology has been the most used at HEIs in the last five years. The authors of the articles highlight characteristics such as efficiency, agility, and flexibility in this type of platform. Digital support or help technology is a set of matured tools that stand out as collaborative tools. AI, BC, and ML dominate emerging DLT.

Review the state of practice in using DLT appropriation models in accredited universities in the city of Medellin. Following the established methodology, we covered 54.56% of the target population, with six people responding to the academic survey and six to the IT area. We found that the strategic objectives of the HEIs are aligned with innovation in DLT, which shows progressive progress with what was stated in [1, 5]. We observed that all HEIs have learning management platforms (LMS), but none have a learning experience platform (LXP). We observe that HEIs have made significant progress in adopting administrative digital technologies. However, lacking LXP platforms signals an opportunity to improve academic administration. The current landscape of emerging digital technologies shows that HEIs are transitioning, gradually allocating more resources to these digital technologies and increasingly training their technological staff. However, we need more references for DLT implantation. Digital assistive technologies are widely used. All the HEIs surveyed have this type of technology, demonstrating a good level of its implantation and use. The reference model proposed in this work presents a valuable guide for appropriating these DLTs, helping HEIs to implant and manage DLTs continuously.

4 Reference Model of Appropriation of Digital Technologies for Learning in HEIs

The proposed reference model guides the appropriation of digital learning technologies in Higher Education Institutions. Developing from the knowledge acquired and the data collected. It consists of two important components called. Digital Learning Technology Adoption is the initial process of researching, acquiring, and accepting digital technologies for learning in HEIs. Digital Learning Technology Adaptation is defined as incorporating DLT into learning and organizational practices.

In the following Figure 1, we see that the proposed model is a process that contains several elements within a large circle divided by two colors: the beige color groups elements belonging to learning digital technology Adoption, and the blue color groups those of the learning digital technology adaptation. Each element within the large circle is associated with a color, representing a role or area (the area groups a set of roles) responsible for acting as the element within the process flow. The color association with the role or area is in the upper left part of Figure 1. The proposed model defines three types of elements, the oval one representing subprocesses, which is described in detail later. A rectangle represents the tasks and specific actions to be carried out by a role or area, and the questions are decision factors for the roles within the great process; a rhombus represents them.

The process begins with a start event represented by a small dark green circle, which triggers a subprocess represented by a blue oval called the Initiative Generator. The output of the Initiative Generator subprocess triggers the Demand Management subprocess represented by a purple oval, which, according to color – role/area referencing information housed in Figure 1 at the top left, belongs to the Demand Manager role. In this logical way, the reading of the process flow progresses. It is essential to highlight that within the incredible process of the model, there are non-continuous colored arrows (blue, red, yellow, and gray) representing the interaction between DLT adoption and adaptation; each interaction is defined as creative synergy and is detailed later.

4.1 Roles or Areas

Initiative Generator This role refers to a group of people (students, managers, administrators, and teachers) who are part of the HEIs and have initiatives associated with academic improvement based on digital technologies. The function of the role is to complete a form where you register your initiative and receive your rejection or approval.

Demand Manager. This role refers to leaders from different departments (services area, computer security, IT infrastructure, and academics). The function of this role is to manage the process of initiatives, receive them, analyze them, and generate their objectives and benefits to meet the need, opportunity, or deficiency. Choose the type of digital technology most appropriate to implant

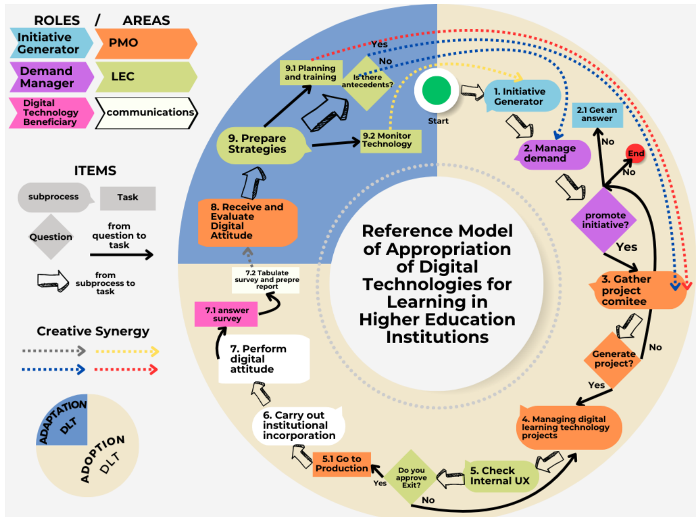

Fig. 1. Reference Model of Appropriation of Digital Technologies for Learning in HEIs. Own elaboration

(manageable, support, or emerging), define its impact and priority, and organize them in this order. This role will meet monthly in a committee to analyze the data entered in the Initiative Form by the Initiative Generator role. Based on the initial information and the analysis, you will fill out the Demand Management Form and decide to decline or promote the initiative. This role reports the decisions made to the Initiative Generator and PMO roles. Will have as a framework [15, 16] DigCompEdu in its seven levels and area Digital Resources areas.

Project Management Office (PMO). This group defines and administers standards for project management and execution, using guidelines from the Project Management Body of Knowledge (PMBOK). It is assigned and led by the IT department, composed of the IT services area, management, and execution of certified PMI-Leaders projects, IT architect, computer security, IT infrastructure, IT director, administrative and financial director, and vice-rector of the academic area. And they are learning. This group accompanies and directs the Adoption and Adaptation of digital learning technology. It has two responsibilities: the Project Committee, where initiatives are evaluated and approved, and those aligned with the strategic objectives, needs, and budget according to a prior evaluation that will guide the Project Committee Form. The second is to define the objectives, benefits, complexity, type of technology to be implanted, the link, and strategic enabler of the project; this is recorded in the Approved Project Form. With these inputs, we will assign a project leader who will act under the reference framework for project management and who, according to the guidelines, will guide the project throughout its cycle and create a work breakdown structure (WBS), baseline of the schedule. . and activities. A working group will give progress to the PMO and close the project.

Learning Center (LEC). This group is assigned and led by the IT department. It comprises an administrator, graphic and content designers, big data (BI) analysts, teachers, IT security leaders, and student representatives. Its function is to manage the knowledge of use and improve the DLT implanted through its management and training of the members of the HEIs, triggering in them the skills of learning techniques so that they can easily take and use the benefits that they bring. It is also a promoter of the implanted digital learning technologies.

The LEC is the catalyst for interactions between the Adoption and Adaptation of DLT. Its first intervention is to approve production outputs; it will function as an internal experience center to evaluate the DLT to implant. This request will be received from the PMO role, which will wait for approval to proceed with the implantation or rejection so that the PMO role in its Manage DLT Projects subprocess can correct it. The second intervention comes from the Receive and Evaluate Digital Attitude subprocess (subprocess of the Adaptation component) and is a generator of strategies to improve the Adoption of Digital technology. The third intervention is of a research nature, carrying out technological surveillance and acting as an Initiative Generator role. The fourth and last intervention will be planning training for the Technology Beneficiary role. The LEC has the mission of training the Technology Beneficiary role to develop technical skills to experience the benefits of digital technology. The reference framework will be DigCompEdu [15, 16], using its competencies, objectives, and activities in its area two Digital Resources and area three Teaching and Learning, the above to generate training and strategies requested by the PMO.

Communications. This group refers to the department communicating HEI events in a clear and unified style, brand, and form to its community and the world.

Digital Technology Beneficiary. This role refers to the people from the student population, administrators, and professors of the HEIs who use and benefit from digital learning technology.

4.2 Model components

Adoption-DLT. Fill out the initiative form. This subprocess begins the model of appropriation of digital technologies for learning in HEIs. The function of the Initiative Generator is to identify a need, deficiency, and opportunity for academic improvement that can be resolved through DLT. For these to be known and materialized, the Initiative Generator role must fill out the Initiative Management form, allowing information to be collected, such as basic data of the proponent, type of link with the HEIs, and type of request (need, lack, opportunity). The idea, its objectives, level of urgency, and if you know of any possible solutions. See details [1]. When the form with the initiative is completed,

[1] https://forms.office.com/r/SwtMqvziY3 section 1

a notification email will be sent to the Demand Manager subprocess role Manage Demand.

Manage Demand. This subprocess begins when an Initiative Management form is completed; a committee analyzes the contribution that the idea makes to digital learning in the university context. Based on this, you will fill out the additional fields enabled for this subprocess in the Demand Management form, where the objective data from the initiative analysis is collected. See details [2]. This role will group initiatives according to their level of impact and benefits. Then, taking into account the analysis of each initiative, the vote will proceed. The voting process of the members of the Demand Management committee will push the initiative to the next level when it reaches 50% + 1 of the participants. After completing these steps, an email will be sent to the lead creator, letting them know if their lead was promoted or disapproved. The promoted initiatives will be sent to the PMO and the Project Committee group. The Demand Management subprocess will also receive the response from the PMO role, where it approves or rejects the initiative(s). This, in turn, will be responsible for informing the initiative-generating role of the response. This subprocess aims to group and filter the initiatives, deciding whether to reject or promote them before the Project Committee.

Gather Project Committee. This subprocess begins when the Demand Manager submits the approved initiatives. In a Project Committee, the PMO evaluates the budget and alignment of the initiative with the university's strategic objectives, benefits, and needs. Based on this, you will fill out the additional fields enabled for this subprocess in the Project Committee form, which will seek to validate all the fields filled out by the Initiative Manager and Demand Manager to issue concepts and proceed to decline or promote the project. Additionally, determine the value of the investment and expense. See details [3]. This committee meets monthly and is comprised of members in the PMO group. After completing the form for each initiative, the vote will proceed. The voting process by the members of the Project Committee will promote the initiative when it reaches 90% of the participants. If the project committee rejects the initiative, it will email the Demand Manager, who will notify the Initiative Manager role. If, on the other hand, the committee promotes the initiative to a project, the Approved Project form will be filled out, which seeks to verify and define the objectives and deliverables of the project, choose technological enablers, academic benefits, level of complexity, estimated execution time, level of priority and impact, type of DLT to implant, strategic link and a project leader will be assigned. See details [4]. This subprocess aims to decline or promote project initiatives, providing the necessary inputs for their creation and implantation.

Managing digital learning technology projects. This subprocess begins when the PMO in the Project Committee approves the initiative and promotes it to a project, assigning a project leader. With the input provided by the PMO

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[2] https://forms.office.com/r/SwtMqvziY3 section2
[3] https://forms.office.com/r/SwtMqvziY3 section3
[4] https://forms.office.com/r/SwtMqvziY3 section4

role, the project leader must create, under the reference framework (PMBOK), a work breakdown structure (WBS), baseline, schedule, activities, and workgroup. With all this information, consolidate the project and request the PMO to approve the start of the project. The project leader will carry out all his management from the beginning of the project until its closure. During the proyect, he will share progress with the project committee. In one of the execution stages of the project, the task Go to Production is contemplated in the schedule. The project leader will request authorization to exit production from the LEC role. This process is detailed in the Verify Internal UX subcomponent. This subprocess is intended to set the path after the initiative is promoted to a project by the PMO role in its Assemble Project Committee subprocess. It defines the leader's particularities, functions, and responsibilities in managing their project.

Check Internal UX. This subprocess begins when the project leader, within the framework of the Manage Project subprocess, requests authorization to start the Go to Production task. The LEC role receives the request via email and will subsequently form a small group with people from the Digital Technology Beneficiary role to carry out tests. The tests will validate the correct functioning of the proposed functionalities, focused on compliance with the stated objectives. After the tests are completed, the LEC role will evaluate the result and decide whether or not to approve the Go to Production task. If it is not approved, an email will be sent with the unfavorable findings of the tests for the PMO role in its Manage Project subprocess so that it can correct and fine-tune the DLT to implant. In this case, it will wait to repeat the test cycle. If approved, the LEC role will send positive consent to the PMO to perform the Go to Production task. It will inform the Communications role that manages the Perform Institutional Onboarding subprocess to continue with the schedule and flow of the model. This subprocess aims to approve or reject the Go to Production task proposed by the project leader. This subprocess helps reduce the risk factors of poor implantation and/or detecting the lack of a proposed functionality. With this validation, the probability of appropriation of the DLT will increase.

Go to Production. This task is executed by the PMO as defined in the activity schedule by the project leader. The prerequisite is that the LEC area approves the release to production. Its objective is to carry out all activities to launch the implantation of the DLT.

Carry out institutional incorporation. This subprocess begins with an email from the LEC role informing the PMO role that the Go to Production task is approved, and in turn, the PMO group begins its deployment. The Communications role will refer to the schedule established by the project leader for the development of its activities, which are during and after the task goes into production. This subprocess seeks to publicize the digital learning technology implanted through the means established by the university institution. Also, carry out activities defined in the schedule by the LEC role. These activities seek to train the university community by demonstrating its benefits and how it adds meaning and improves the academic process. This subprocess aims to establish the purpose and responsibility of the communications role in the model within the project management framework.

Perform digital attitude. This subprocess begins when the Communications role completes the proposed activities of the Perform Institutional Onboarding subprocess. After a time established in the project schedule to complete the Go to Production task, the Digital Attitude survey is carried out on the Technology Beneficiary role. This survey seeks to obtain feedback on the implanted DLT, with questions about its ease of access, use, and functionalities, if it contributes to your academic experience if you find shortcomings and opportunities for improvement, and if you are interested in acquiring it. More excellent knowledge about the technology implanted.

Answer Survey. This task is carried out by the Beneficiary of the digital technology role, completing the Digital Attitude survey, see details [5].

Tabulate Survey and Prepre Report. The Communications group will receive the surveys completed by the Beneficiary of the digital technology role, tabulate them, and prepare a report, which will be sent by email to the PMO role to two subprocesses: Receive and evaluate the Digital Attitude and to the Manage Project subprocess of the DLT, for the closure of the project. This subprocess is intended to receive feedback from the Technology Beneficiary role. This information will be taken as input and will initiate the interaction (creative synergy) between DLT Adoption and Adaptation. Solutions based on this input seek to be the catalyst for appropriation and must strengthen the role of Technology Beneficiaries through training. Also promote the role of LEC in technological surveillance and the generation of new projects that allow the continuous adaptation of the implanted DLTs. This subprocess culminates the DLT Adoption component and will be an input to the first DLT Adaptation component.

Adaptation – DLT Receive and Evaluate Digital Attitude. This subprocess begins when the Communications group in the DLT Adoption component, Tabular Survey and Make Report thread, sends the result by email to the Receive and Assess Digital Attitude thread. The PMO will evaluate the Digital Attitude. This defines the first of four ways the DLT Adoption and Adaptation interaction cycle occurs (creative synergy), represented by the dashed gray arrow. In this first interaction, all the feedback on what was done in the DLT Adoption is received and will serve as input for the lessons learned. This analysis will lead to improvements, redefinitions, updates, or adaptations to the implantation of DLT. This type of analysis will be delivered to the LEC with the needs and objectives to develop strategies by what the PMO requests, setting the path for the next three interactions. This subprocess aims to evaluate the feedback in the Digital Attitude surveys and take action, activating the interaction between DLT Adoption and Adaptation through the proposed roles.

Prepare Strategies for the LEC. This subprocess starts when the PMO role emails the survey analysis to the LEC role. The latter will review it and, based on it, verify whether or not there is any history of a similar strategy already

[5] https://forms.office.com/r/rmJvUAnM7q

applied. If there is no precedent, we will develop a strategy according to the analysis presented by the PMO role to strengthen the acquired benefits and/or correct the deficiencies. This proposal, without background, will be presented to the Demand Manager Role in the Manage Demand subprocess through the Initiative Form. See details [6].The Demand Manager role receives the strategies developed by the LEC and will evaluate them as already established in the Manage Demand subprocess. On the other hand, if we previously applied a successful strategy to a similar behavior, we will value and adapt it to the current need. We will present this proposal with background to the PMO role in its Perform Project Committee subprocess. The PMO role will carry out its study as established in the subprocess, supported by the Project Committee Form. See details [7]. IThis defines the second interaction between DLT adaptation and adoption (creative synergy), represented by the dashed blue arrow. We will save all proposed strategies in a knowledge database. In its planning and training task, the LEC group will design training plans for the IES members in the implanted DLTs and provide training to the technology's Beneficiary Role. We will develop this task under the DigCompEdu framework, as described in the LEC group's definition. These training plans will be presented to the PMO role in its Perform Project Committee subprocess. The PMO role will carry out its study as established in the subprocess, supported by the Project Committee Form. See details [8]. This defines the third way in which DLT Adaptation and DLT Adoption interact (Creative Synergy), represented with the red non-continuous arrow. In its task of Monitoring Technology, the LEC role will evaluate the implanted DLT, verifying what innovations or functions there are. She will also verify new DLT that better meet the current need and can be adaptable to the IES. This search will result in an initiative, which will be presented to the Demand Manager Role in the Manage Demand subprocess through the Initiative Form. See details [9]. This will be the fourth way DLT Adaptation and DLT Adoption (Creative Synergy) interact, represented with the non-continuous yellow arrow.

Creative Synergy. We saw how DLT Adaptation and DLT Adoption interact in the previous two sub process. These interactions always give rise to new initiatives aimed at making DLT appropriate and personalized based on the need for improvement or innovation. Suppose DLT is given different uses than the initially proposed objectives, and these new uses help improve the academic development of the Beneficiaries of Digital Technology within HEIs; this is when the limits are broken. In that case, we start showing DLT Appropriation.

4.3 Metrics

Compliance with the stated objectives. The project management metric (PMM) measures the effectiveness of executed projects. It is measured by the number of objectives met over the number of objectives set for the project.

[6] https://forms.office.com/r/SwtMqvziY3 section1
[7] https://forms.office.com/r/SwtMqvziY3 section 3
[8] https://forms.office.com/r/SwtMqvziY3 section 3
[9] https://forms.office.com/r/SwtMqvziY3 section 1

Technology Adoption Rate. The technology adoption rate (TADOPT) measures the active use of the implanted digital technology. It is measured by the number of active users over the number of potential users.

Technology correctness rate. The technology correctness rate (TCT) measures the reliability of the implanted digital technology. It is measured by the number of errors presented over the number of expected errors.

Technology acceptability rate. The technology acceptability rate (TACEPT) measures users who are willing to accept and use the implanted digital technology based on five factors: Perceived ease of use (PEOU), Perceived usefulness (PU), Quality of the system (QoS), Perceived Enjoyment (PEnj) and Intention to Use (ITU) according to [34]. This data will be obtained through surveys of the beneficiaries of digital technology to measure each related factor using the Likert scale [35], focusing on questions for each factor. It is calculated as follows: number of users who accept the technology over the total number of users evaluated.

Technology Adaptation Rate. The Technology Adaptation Rate (TADAPT) measures users who personalize and adjust implanted digital technology to improve their learning practices. It is calculated as follows: number of users who personalize the DLT over the total number of users evaluated.

5 Blockchain Pilot Case Study-Formal Education Degrees

To validate the proposed model, an accredited university in Colombia based in the city of Medellín was chosen. It currently uses the PMI reference framework (PMO-PMBOK) with its strategic guidelines for managing projects involving digital technologies. This university carried out a project in 2023 called Blockchain Pilot - Formal Education Degrees, in which Blockchain digital technology was implanted to issue diplomas and degree certificates.

The proposed model was used to monitor the project regarding the inclusion or not of good practices for appropriating digital technologies for learning. For this, several activities were carried out, such as understanding the process used for implanted digital technology, meetings were held with different actors who participated in the project's development, and the university provided access to all project documentation and end-user surveys of digital attitude, of problems presented, and lessons learned. Additionally, a survey was applied to these actors to consolidate and use the metrics proposed in our model: compliance with the stated objectives, technology adoption rate, and satisfaction with the digital learning technology implanted, which resulted in the following analysis.

6 Results

Applying the proposed model to the case study yielded the following results: The model allowed the management of the blockchain pilot project—formal education titles—to be validated through the PMM metric. The indicator was 100%. Two objectives were set, and two were met, which gave rise to high appropriation after the project's completion.

The model made it possible to validate, through the TADOPT metric, the active use of blockchain digital technology to issue degrees and degree certificates. The indicator was 80%. Of the 100 users surveyed, 80 used digital technology and completed their interaction satisfactorily. 20%, 20 people, had problems using digital technology and did not finish the interaction comfortably.

The model allowed us to validate, through the TCT metric, the reliability of the implanted digital technology. The indicator was 65%. Of the 100 users surveyed, 65 completed their use without errors, and 35 presented problems such as duplicity in the requested certificates or errors in the platform that did not allow the flow to be completed satisfactorily.

The model allowed us to validate, through the TACEPT metric, the users willing to accept and use the implanted digital technology. The indicator was 60%. Of the 100 users surveyed using the (reference) scale, 70 accepted the implanted digital technology, and 30 would not use the technology again.

7 Discussion and Conclusions

The model of appropriation of digital technologies for learning proposed in this work offers a framework to address and optimize the transformative potential of digital technology in higher education. The adoption of this model provides consistency through the flow constituted by all its elements for their interaction, significantly increasing academic improvement because it facilitates the integration of digital technologies, such as artificial intelligence, machine learning, and blockchain, enriching learning practices. Furthermore, this approach would promote student collaboration and participation, making teaching and learning more relevant.

The good practices proposed and the international reference frameworks included in this work help to contribute to the model and the creative synergy in a structured and continuous way. In [20], success was found in creating a support center for teachers and students, which they now base as a pillar of academic improvement through digital technologies. With this foundation, the LEC group was created as a catalyst for the appropriation of DLT in our model. The above leads to the conclusion that: · It was feasible to find academic literature concerning the appropriation of digital technologies in the context of learning for HEIs. This enabled an understanding of the challenges and practices that influence academic improvement. · It was possible to find scientific studies with characteristics and components that facilitated the appropriation of digital technologies and compare this with the data collected through the surveys carried out, allowing the development and integration of the components that are part of the proposed reference model. · The proposed model was developed, which consists of two components: DLT Adoption and DLT Adaptation. The interaction of these with good practices from international reference frameworks results in appropriating digital technologies for learning. · The proposed model was validated against an accredited university in Colombia based in the city of Medellín. Uses the PMI (PMO-PMBOK) framework as a strategic guide for managing digital technology projects. Our model is relevant in executing digital technology projects for learning, providing strategic guidelines for its appropriation in different academic contexts.

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