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Implementing e-Learning for Knowledge Dissemination in a geographically dispersed organization

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Abstract. Training employees in organizations is essential for enhancing productivity and profitability, updating their knowledge, and better preparing them for market demands. Through digital platforms (LMS) and the e-Learning method, training occurs in web-based environments, enabling content management and accessibility across multiple devices. e-Learning typically follows a modular structure, ensuring adaptability, flexibility, and asynchronous learning. This study applies to the Design Science Research method to implement a data protection training course via an LMS, facilitating knowledge dissemination and employee self-assessment. The organization faces challenges in rapidly spreading knowledge due to its widespread locations, diverse working hours, and geographical constraints. The study evaluates training dissemination through microlearning, leveraging Moodle (LMS) and Digital Storytelling techniques. Additionally, it assesses the pedagogical and engagement aspects to ensure training is efficient, standardized, flexible, and more appealing to employees, increasing their receptivity and interest.

Keywords: e-learning, microlearning, learning object, digital storytelling, learning management system

1 Introduction

This study aims to analyze not only the concepts related to knowledge management technologies in organizations and e-Learning but also the information systems used for knowledge dissemination. The research seeks to expand the scientific understanding of knowledge diffusion in organizations, focusing on a specific case study while addressing variables that challenge conventional training models.

The organization under study is Fundação INATEL, a private foundation of public utility under the supervision of the Portuguese Ministry of Labour, Solidarity, and Social Security. It carries out leisure activities, particularly in social tourism, popular culture, and amateur sports. Due to the nature of its operations, Fundação INATEL maintains public service locations in all district capitals, as well as hotel units and cultural and sports venues across the country. Given its geographically dispersed workforce, the foundation must regularly disseminate knowledge using the best available practices and technologies. To address this need, this study proposes the implementation of a self-training course in a microlearning format, using Personal

Data Protection as an example topic. In an organizational environment with unique characteristics, where digital training methods can streamline remote and asynchronous learning, this research aims to assess whether current technologies enable the rapid and efficient delivery of training.

A key challenge identified in the organization is the need to disseminate knowledge on data protection, ensuring compliance with existing legislation while improving the efficiency and effectiveness of customer interactions. This study will explore technological concepts and methods that enable the organization to reduce the time required for training implementation and knowledge dissemination, particularly through Digital Storytelling methodologies to facilitate rapid and engaging learning experiences for employees.

2 Research Methodology

This study adopts the Design Science Research (DSR) method, which enables the creation of artefacts that address real-world problems while contributing to scientific knowledge advancement. DSR is particularly suitable for the development of technological artefacts, as its pragmatic approach helps solve concrete organizational challenges [1].

Given the research problem and corresponding questions, this study employs both DSR and a Systematic Literature Review (SLR) as its primary research methodologies. DSR follows an iterative process, utilizing available resources to achieve desired outcomes while adhering to environmental constraints [2]. Although understanding how the designed artefact resolves the identified problem is crucial, the critical nature of design in information systems makes it essential to define the artefact's functionality and characterize its performance within specific contexts, even when complete information on the process is not available [1] [2].

SLR, as described by Kitchenham [3], is a structured approach to identifying, evaluating, and interpreting scientific articles relevant to a specific research question, topic, or phenomenon. The motivation for conducting an SLR lies in its ability to summarize existing evidence about a given technology, identify knowledge gaps, and provide a framework for further research. Additionally, SLRs can be used to examine the extent to which empirical evidence supports or contradicts theoretical hypotheses and to aid in the development of new knowledge.

2.1 Definition of the Research Problem and Key Questions

This research seeks to evaluate the efficiency of methodologies and technologies in accelerating knowledge transfer within the organization. Beyond generating scientific knowledge, it aims to assess its practical applicability within the case study.

To address the challenges identified, the following Research Questions (RQs) have been formulated:

RQ1: What are the benefits of implementing and using microlearning in professional training contexts?

RQ2: Can SCORM and xAPI enhance the speed of multimedia content design and implementation in a Digital Storytelling format?

RQ3: What factors contribute to failure or resistance in the adoption and execution of microlearning within an organization's specific training program?

RQ4: How does an employee's perception of their pedagogical evaluation impact their learning experience in a microlearning self-training program?

2.2 Systematic Literature Review Process

Formulating research questions facilitates the identification of search keywords by translating these questions into their key concepts. To achieve this, the PICOC framework was used to define search terms. PICOC stands for Population, Intervention (or Problem), Comparison, Outcomes, and Context [4].

Multiple iterations of these search terms were conducted across different databases to ensure the retrieval of relevant articles. The Population (G1), Intervention (G2), and Context (G3) were identified as key term groups. In contrast, no terms were defined for Comparison or Outcomes, as PICOC allows these fields to remain empty when necessary [4]. To ensure a comprehensive and high-quality search, relevant synonyms for the identified terms were structured and applied to the queries. Searches were conducted in the Ebsco, Scopus, and Web of Science databases using search keywords and their synonyms from the research questions.

Using the constructed search string {ABS (("microlearning" OR "micro-learning" OR "micro learning" OR "learning object" OR scorm OR "sharable content object" OR xapi OR "digital storytelling" OR "professional training" OR "distance training" OR "online training") AND ("learning management system" OR lms OR "learning content management system" OR lcms OR moodle OR "learning platform"))}, a total of 407 articles were retrieved, distributed as follows: Ebsco: 277 articles; Scopus: 64 articles; Web of Science: 66 articles.

In this second phase of the SLR, articles were selected, data were extracted, and a rigorous and impartial synthesis was conducted. The retrieved articles were filtered using Rayyan, a web-based tool for systematic reviews [5]. The inclusion and exclusion criteria were applied to refine the selection process. After removing duplicates, 285 unique articles remained. By reviewing the abstracts, the list was further reduced to 27 articles deemed relevant to the study. Following a full reading of these articles, the final selection was narrowed to 22 articles containing valid content to address the research questions. Additionally, an index of quality was initially considered to evaluate the suitability of the selected articles. However, due to the effectiveness of the inclusion and exclusion criteria, its implementation was deemed unnecessary.

2.3 Discussion

Training processes are essential for organizations to keep pace with the rapid evolution of knowledge [6]. The adoption of web and mobile technologies has become a standard practice in e-Learning, driven by the need to optimize time across preparation, implementation, worker allocation, course duration, and feedback collection [7] [8] [9] [10]. Studies confirm that e-Learning grants learners autonomy, ensuring they acquire the necessary skills for new tasks while maintaining access to knowledge for on-the-job support [11] [12] [13] [14]. Given this, digital learning resources must always be available to facilitate correct task execution [15].

SCORM and xAPI are among the key technical standards for e-Learning objects, with SCORM pioneering solutions for interoperability between systems [16] [17]. xAPI, often called "mobile SCORM," builds upon SCORM's framework while adapting to modern mobile and digital environments [16] [17]. These standards support multimedia, interactivity, and automation, enabling methodologies such as Digital Storytelling, which fosters immersive and motivational learning experiences [16] [17]. Additionally, microlearning, defined as "a short engagement in a deliberately designed activity for a specific learning outcome" [9], delivered via Learning Management Systems (LMS), offers a rapid and cost-effective way to provide just-in-time knowledge [18] [6]. This approach facilitates both formal and informal learning, whether collaborative or individual, allowing access to training anytime and anywhere [9].

Feedback in e-Learning plays a critical role in learner self-correction and performance improvement, compensating for the absence of direct instructor guidance [19] [8]. Effective feedback mechanisms enhance learner satisfaction, reinforce self-awareness, and ensure the pedagogical design is evaluated for its impact on both employees and organizational performance [20] [13] [21] [10]. However, implementing e-Learning is not solely a technological challenge; it requires a multidisciplinary organizational approach to ensure successful LMS adoption [10]. Language, terminology, and digital literacy are key factors influencing acceptance, whereas flexible access to training significantly enhances engagement [6]. Post-implementation reviews are crucial to assess the value and effectiveness of training processes within the organization [21].

2.4 SLR conclusions

This study explores the technological, pedagogical, and organizational aspects of e-Learning in geographically dispersed organizations, assessing training effectiveness, time optimization, and technological integration. It promotes learner autonomy through microlearning and Digital Storytelling with automated feedback while examining SCORM and xAPI interoperability. Additionally, it addresses the balance between technology and human factors, ensuring alignment with workers' needs and overcoming challenges related to digital literacy, resistance to change, and system adaptation to evolving trends. The research questions RQ3 and RQ4 have been reformulated to better support the scientific objectives of this study.

RQ3 now asks: "What are the organizational and individual factors that influence the adoption, acceptance, and effectiveness of microlearning as a training model within organizations?" This reformulation expands the analysis beyond mere failure or resistance to include organizational factors such as alignment with the organization's vision, mission, and strategic training planning, as well as stakeholder involvement in content development [11] [10]. It also considers individual factors such as workers' perceptions of training value, motivation, and challenges related to digital literacy and adapting to new learning methodologies [6] [22]. Additional aspects include implementation barriers like technological integration issues, lack of incentives, difficulties in creating relevant instructional materials, and the risk of learning isolation [23] [9] [10]., along with motivators for success such as format flexibility, opportunities for continuous improvement through data collection, interactivity, and content personalization based on the worker's profile [24] [12] [6].

RQ4 has been reformulated to investigate: "How does the worker's perception of their pedagogical evaluation in self-directed microlearning influence their motivation, satisfaction, and performance during the training process?" This question recognizes that knowledge assessment plays an essential role in learning [19], with feedback being critical for error correction, knowledge enhancement, and motivation reinforcement [20] [13] [10]. Microlearning's provision of immediate feedback facilitates self-directed learning, which is particularly significant in e-Learning environments where face-to-face interaction is replaced by virtual engagement [19] [8]. Moreover, the clarity of the training design, ease of interaction with the content, and potential for personalization are key factors that influence course effectiveness and learner satisfaction [15] [13] [9]. Negative perceptions of evaluation can demotivate learners and impair knowledge retention, thereby making it imperative to explore how pedagogical evaluation impacts both the adoption and continuity of self-directed microlearning [21] [10].

3 Literature Review

3.1 e-Learning in Organizational Contexts

e-Learning refers to the ability to digitally transfer, manage, support, and monitor training materials and learning processes [25]. It is a highly effective tool for employee development, offering enhanced accessibility, cost-efficiency, and up-to-date content [8] [6] [9]. Defined as an interactive learning approach, e-Learning ensures that content is available online, often incorporating automated feedback [26]. Learning materials are typically digital, multimedia-based [11] [21], and interactive, providing a blend of informative, demonstrative, and practical learning experiences [8]. It serves as a tool for autonomous learning [11] [8] [12] [13] [14], reference material for ongoing consultation [27] [8] [12] [6], and a method for decision-making training and knowledge control [11] [8] [13] [14].

Organizations are increasingly adopting LMS to oversee training and communication processes [7] [9] [10]. Given the rapid evolution of knowledge, employees and organizations must continuously adapt to remain competitive [6]. However, misconceptions regarding the implementation and use of e-Learning can lead to project failure [25]. Ensuring the correct application of LMS platforms and training methodologies is critical for achieving the intended outcomes.

Security risks associated with LMS platforms also play a crucial role in the success of e-Learning projects. Standard security practices include restricted access, minimized web exposure, and the use of corporate credentials to prevent unauthorized access [28]. These measures ensure that digital learning environments remain secure and protected, preventing data breaches and maintaining the confidentiality of training materials.

Training is a fundamental pillar for an organization's survival and competitiveness [15]. As businesses integrate more technology into their operations, their vision, mission, and objectives must align with the chosen digital tools [10]. e-Learning is recognized as a highly effective and productive method for employee development [21], improving time management, speed, and cost-efficiency [8] [6] [9]. Additionally, it is particularly beneficial for organizations with geographically dispersed employees [8] [15] or those requiring training without direct instructor-student interaction [14].

The success of e-Learning implementation depends on multiple factors, including perceived usefulness, ease of use, promotion, engagement, organizational culture, and genuine necessity. Additional considerations such as time investment, support, mandatory participation, and incentives also influence outcomes [28] [25]. While return on investment (ROI) is a key performance metric, its direct correlation to corporate financial gains may not always be measurable. For instance, while online training may improve user interaction with a product, it does not necessarily drive market growth [28].

3.2 Microlearning

In today's fast-paced world, the pursuit of efficiency and effectiveness in workplace learning has led to the development of methodologies that enhance productivity and save time. One such approach is microlearning, which delivers knowledge in small, focused units designed for quick consumption [29]. Often referred to as an agile "just-in-time" learning tool, microlearning addresses the challenge of information overload by providing concise, engaging, and interactive content [6] [9]. This method is characterized by its flexibility, accessible anytime, anywhere, on any device, making it an asynchronous and ubiquitous learning solution [29]. Employees tend to retain information more effectively when exposed to short, structured lessons rather than lengthy training sessions [9]. This is why microlearning is increasingly used in corporate environments to accelerate skill development [29].

Microlearning enhances the learning process by reducing the likelihood of disengagement or dropout [6]. It is defined by several key characteristics: Time – short learning sessions requiring minimal effort [6] [9]; Content – small, well-defined units addressing simple topics [6] [9]; Curriculum – modular elements that can be easily managed within an LMS [6] [9]; Format – diverse formats, including bite-sized learning materials [6]; Process – independent activities or iterative learning cycles [6]; Communication – in-person or digital delivery through multimedia content [6]; and Learning models – incorporating repetition, reflection, pragmatism, constructivism, or conceptual learning [6]. Different formats and interactive content significantly enhance employee engagement and knowledge retention [9].

Although microlearning is not suitable for all training contexts, it remains a powerful tool for knowledge dissemination in organizations [18] [6]. It offers flexibility, allowing employees to access training at their own pace reinforcing learning in stages [29]. Its benefits include ubiquity [24] [6] [21], real-time data collection for training enhancement [24] [10], interactivity [12] [6], adaptability [24] [8], and improved focus by minimizing distractions [12] [6]. Additionally, its short, structured format aligns with short-term memory processing [15] [6] and facilitates continuous knowledge updates through repetition and practice [6]. The effectiveness of microlearning depends not only on content design but also on the incorporation of motivational strategies to sustain learner engagement [12] [15] [22] [21].

3.3 Development of e-Content

Cyberspace serves as a domain for cyberculture practices, guided by three core principles: emission, which enables mass communication and unrestricted individual expression; connection, characterized by global communication systems; and social, cultural, and political reconfiguration, allowing for open models, multimedia production, and public opinion formation [30]. One of the primary challenges in workplace learning is the lack of easily implementable mechanisms for knowledge transfer, particularly in the face of corporate changes [15].

Instructional Design (ID) is a key methodology for developing training content [31] and shaping online education and training through structured didactic planning [32]. ID theories establish a dichotomy between two pedagogical paradigms: the traditional model (industrial era), where knowledge is acquired through standard instruction methods focusing on memorization and application; and the constructivist model (information era), where knowledge is built through personalized learning supported by digital technologies [32]. ID follows a step-by-step process to assess learner needs, design and develop content materials, and evaluate outcomes [31]. Among the numerous instructional models, the most prominent include Jonassen's CLE, which fosters critical thinking and multiple perspectives; Merrill's model, which engages learners in real-world problem-solving; Keller's ARCS, which focuses on motivation; Kemp, Morrison & Ross, which integrates formative and summative assessment; ADDIE, a structured military training model; and R2D2, a recursive, non-linear constructivist approach [31] [32].

Before designing e-Content, subject-matter experts must define pedagogical objectives, module structures, and sequential learning paths [31]. Professionals involved in e-Content development possess a range of competencies across technical (e.g., multimedia integration, programming), design (e.g., ID, graphic design), tutorial (e.g., e-Learning support, content review), and management (e.g., project coordination, training needs assessment) domains [33]. Their roles ensure that e-Content is pedagogically sound, technologically robust, and effectively delivered within digital learning environments.

e-Content can be developed using various media types, including script-based content (text, images), audio content (spoken information), video content (dynamic visuals for engagement), and multimedia content (a combination of different formats) [31]. The design of e-Content must align with pedagogical principles, usability, and technical specifications, ensuring that learners comprehend, apply, and retain knowledge effectively. To achieve these outcomes, ID strategies must include structured instructional goals, modular sequencing, activity planning, and continuous assessment [31].

The development of e-Content follows a structured five-phase process adapted from the ADDIE model: Analysis, which involves content mapping, course structuring, and user needs assessment; Design, where interfaces, templates, and learning methodologies are defined; Development, which focuses on creating the instructional content; Standardization, ensuring compliance with e-Learning standards such as SCORM and xAPI for interoperability; and Integration, where the content is deployed within a LMS and undergoes usability testing [31].

Collaboration across organizational departments enhances the acceptance and effectiveness of e-Learning initiatives [6]. Quality assurance in e-Content development is measured through three evaluation levels: pedagogical evaluation, assessing knowledge acquisition through diagnostic and summative assessments; training evaluation, analyzing user satisfaction and training relevance; and effectiveness evaluation, determining the ROI of training within the organization [31]. By ensuring strategic instructional planning, rigorous assessment, and continuous improvement, organizations can maximize the impact of their e-Learning initiatives.

3.4 e-Learning technologies (LMS, SCORM, xAPI)

A LMS is a digital platform that allows organizations to create, store, manage, and distribute learning objects (LO) [26]. These systems facilitate educational communication, track user activity, and support both synchronous and asynchronous learning [34] [35]. They offer functionalities such as enrolment management, course administration, assessment tools, and learner progress tracking [36]. LMS solutions enhance organizational learning culture by reducing training costs and providing continuous access to educational resources [37]. However, many LMS platforms lack built-in tools for creating LOs, leading providers to offer complementary content development tools or partnerships [36].

To ensure interoperability, reusability, and durability of e-Learning content, the Advanced Distributed Learning (ADL) Initiative developed SCORM (Sharable Content Object Reference Model) [38]. SCORM establishes technical standards for communication between LMS platforms and LO without dictating ID [39]. SCORM objects consist of assets (e.g., videos, text, images), shareable content objects, and content aggregations [24] [40]. Five SCORM versions exist, with SCORM 1.2 and SCORM 2004 3rd Edition being the most widely used [39]. SCORM ensures standardized content delivery through features such as interoperability, portability, reusability, and sequencing [18]. Despite its advantages, transferring SCORM-based LOs across LMS platforms may involve compatibility challenges and additional costs [28].

To expand tracking capabilities beyond SCORM's limitations, ADL developed the Experience API (xAPI), also known as Tin Can) [38]. Standardized by IEEE in 2020, xAPI enables data collection from diverse learning experiences, both online and offline, including simulations, mobile apps, video interactions, and real-world activities [18] [40] [39]. It supports ID enhancements such as collaborative exercises and direct instructor intervention [8] [15]. Unlike SCORM, which focuses on standardizing content packaging and communication, xAPI collects learning experience data in a flexible and scalable manner [39]. Security and privacy are central to xAPI, with built-in measures for data integrity, authentication, and encryption [39].

Despite advancements in e-Learning standards, full compatibility between LOs and LMS platforms remains a challenge, often requiring system customization or reliance on specific technologies [28]. The effectiveness of LMS adoption depends not only on system quality but also on the implementation of engaging content and services that enhance user satisfaction [34]. Additionally, training educators to use LMS tools effectively can further motivate learners and maximize the benefits of e-Learning technologies [35]. By integrating LMS, SCORM, and xAPI, organizations can optimize learning experiences, ensure content longevity, and facilitate continuous professional development.

4 Artefact design

According to DSR studies, artefacts created through this methodology are not fully developed information systems but innovations that define ideas, practices, technical capabilities, and products for effective and efficient system design and implementation [1] [41]. This chapter identifies key functionalities for an initial, adaptable prototype that has been developed iteratively to address the problem. Its design and technical development will be structured based on prior research and implemented using authoring tools.

4.1 Artefact requirements

In microlearning training using Digital Storytelling, learning objectives play a crucial role in shaping content and pedagogical strategies. Based on SLR findings, these objectives must be specific, clear, and focused due to the short interaction time, as shown in Table 1. At the same time, Digital Storytelling ensures engaging, structured narratives that effectively convey concepts and skills.

Table 1. Generic requirements for e-Content and their relationship to SLR

Generic requirements	Relevance to the research question	Article Reference
Have a short training time, Microlearning.	RQ1 RQ2 RQ3 RQ4	[18] [15] [6] [9]
Collect data from learners' interactions.	RQ1 RQ2 RQ3 RQ4	[24] [11] [18] [16] [40] [9] [10]
It must have informative, demonstrative, and practical support material.	RQ1 RQ2 RQ3	[24] [40] [27]
Available and accessible anytime, anywhere.	RQ1 RQ2 RQ3	[24] [11] [18] [6] [22] [21]
The content should be empathetic and presented in a narrative with a structured and engaging	RQ1 RQ2 RQ3	[11] [13] [14]

Generic requirements	Relevance to the research question	Article Reference
sequence.		
Be developed in SCORM and xAPI technologies.	RQ1 RQ2 RQ3	[11] [18]
Be developed in web technology LMS.	RQ1 RQ2 RQ4	[7] [9] [21] [10]
Use the e-Learning methodology.	RQ1 RQ2 RQ4	[8] [6] [9] [21]
Have a pedagogical evaluation to verify the state of knowledge after the training is executed.	RQ1 RQ2 RQ4	[19] [20] [13] [10]
Its content is self-explanatory (allowing the acquisition of knowledge without a trainer).	RQ1 RQ3 RQ4	[16] [9]
Allow the trainees autonomy throughout the training.	RQ1 RQ3 RQ4	[19] [8] [9]
Be able to provide feedback on the knowledge acquired.	RQ1 RQ3 RQ4	[12] [6]
Enable preparation and deployment time contention.	RQ1	[8] [23] [6] [9]
Use the Digital Storytelling training method.	RQ2	[42] [16] [17]
Have an assessment of the surroundings to confirm the acceptance of the applied model.	RQ3 RQ4	[21]

4.2 Scientific content of GDPR

The aim is for the organization's employees to acquire the knowledge to record the organization's customer data correctly. The workers targeted for this training are all those involved in handling customer data, i.e., all those working in customer service and the back office. As identified in the training motivation, the accuracy and updating of data entry is mandatory for compliance with the GDPR, as described in Article 5(1)(d) - 'Personal data shall be: ... accurate and kept up to date where necessary; all appropriate measures must be taken to ensure that inaccurate data, having regard to the purposes for which they are processed, are erased or rectified without delay ...' [43].

4.3 Storyboard of the training course

Creating a storyboard for a course or module is essential for structuring the learning flow, ensuring that information is effectively organized for sequential learning [31]. It provides implementers with detailed guidance on designing activities, exercises, and assessments, enabling a smooth and coherent implementation aligned with the intended learning objectives. The process should address key questions, such as the most suitable content structure, the best strategy for information segmentation, the integration of constructivist principles to enhance interaction, appropriate feedback mechanisms, optimal navigation design, and the selection and timing of multimedia elements [31]. Various digital tools can streamline the storyboard creation process, allowing for easy adjustments without restarting from scratch.

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Table 2. Comparison of Storyboard Creation Software

Software	Licensing	Compatibility	Open Source	Official link
Adobe (Photoshop, Illustrator)	Paid	Windows, macOS	No	adobe.com
Canva	Paid /Free	Web (Cloud), Windows, macOS	No	canva.com
Concepts	Paid /Free	iOS, Android	No	concepts.app
Draw.io	Free	Web (Cloud), Windows, macOS, Linux	Yes	draw.io
FrameForge Storyboard Studio	Paid	Windows, macOS	No	frameforge.com
Google Slides	Free	Web (Cloud), Windows, macOS	No	google.com
LibreOffice (Impress, Draw)	Free	Windows, macOS, Linux	Yes	libreoffice.org
Microsoft PowerPoint	Paid	Windows, macOS	No	microsoft.com
Procreate	Paid	iPadOS	No	procreate.art
Storyboard That	Paid /Free	Web (Cloud), Windows, macOS	No	storyboardthat.com
Toon Boom Storyboard Pro	Paid	Windows, macOS	No	toonboom.com

These tools, as identified in Table 2, offer features such as annotations, scene marking, animation capabilities, and enhancing clarity and interpretation. Additionally, digital storyboards facilitate efficient teamwork, ensure access to up-to-date materials, and support version control. Some tools also provide predefined templates, image libraries, and customization options, making the process more efficient. The course content will be structured according to the methodology outlined in Figure 1, organized into topics and content units.

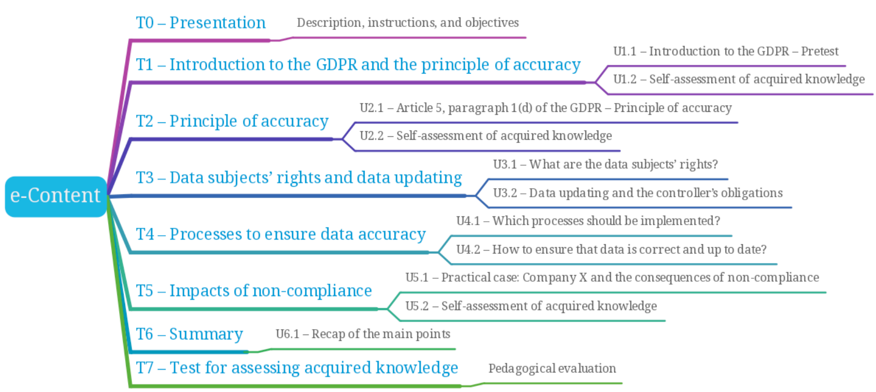

Fig. 1. Training content structure

4.4 Developing the Artefact

In developing the preliminary version of the artefact, previous studies were considered, with a particular focus on Microlearning specifications, the requirements identified in the SLR, Digital Storytelling, e-Learning technologies (LMS, SCORM, xAPI), the e-Content development cycle, and storyboarding.

Although a multidisciplinary team should undertake e-Content creation, the present LO and all its multimedia elements were developed solely by the author. To meet the requirements identified, an LMS was necessary to support e-Content operationalization, ensuring accessibility and interactivity. The organization where self-learning will take place has Moodle installed as its LMS. While other LMS alternatives exist, as shown in Table 3, the organization Moodle instance was recently implemented, remains fully functional, and does not require regular maintenance. Thus, rather than deploying a new LMS, the focus is on developing e-Content that is concise, coherent, and aligned with the subject matter. This Moodle instance does not have an integrated or associated LRS, which was deemed unnecessary since all artefact interactions occur within the LMS itself.

Table 3. Comparison of Learning Management Systems (LMS)

LMS	Code	Licensing	Open source	On-premises	Support	Integrations	Official link
Blackboard	Java	Paid	No	Yes	Paid	(A) (B) (C) (D) (E)	blackboard.com
Canvas	Ruby on Rails	Paid /Free	Yes	Yes	Paid /Community	(A) (B) (C) (D) (E) (F)	instructure.com
Chamilo	PHP	Free	Yes	Yes	Paid /Community	(A) (B) (C) (D) (F)	chamilo.org
Dokeos	PHP	Paid /Free	Yes	Yes	Paid /Community	(A) (B) (C) (D) (G)	dokeos.com
ILIAS	PHP	Free	Yes	Yes	Paid /Community	(A) (B) (C) (D) (F)	ilias.de
Moodle	PHP	Free	Yes	Yes	Paid /Community	(A) (B) (C) (D) (F) (H)	moodle.org
Open edX	Python	Free	Yes	Yes	Paid /Community	(A) via plugin (B) (C) (F) (G)	openedx.org
SAP Litmos	JavaScript	Paid	No	No	Paid	(A) (B) (C) (G) (H)	litmos.com
TalentLMS	PHP	Paid	No	No	Paid	(A) (B) (C) (D) (G) (H)	talentlms.com

SCORM 1.2 (A); xAPI (B); H5P (C); LDAP (D); API REST (E); LTI (F); API (G); SSO (H)

Moodle is one of the world's most widely used LMS platforms, with over 300 million users in more than 160,000 institutions globally [44]. Launched in 2002 as open-source software, it is known for its flexibility and strong presence in universities, schools, businesses, and government institutions. With a large community of

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developers and users, Moodle benefits from continuous updates, active support, and a broad selection of plugins and customization options, making it highly adaptable. The platform offers interactive learning environments, including forums, quizzes, gamification, and mobile access for students while providing course management, assessment tools, and communication features for instructors. Administrators benefit from high configurability, allowing permission management, interface customization, and detailed performance monitoring.

Furthermore, Moodle supports instructional standards such as SCORM, xAPI, and LTI, ensuring seamless e-Learning content integration. From a technical standpoint, Moodle is built in PHP, operates with MySQL or PostgreSQL databases, and supports both on-premises and cloud installations. Its modular architecture enables functionality expansion via plugins, with native integrations for LDAP, Single Sign-On, Office 365, Google Workspace, and video conferencing tools like Zoom and Microsoft Teams.

Table 4. Comparison of authoring tool software

Software	Operating System /Platform	Licensing	Open source	Export formats	Support	Official link
Adobe Captivate	Windows, macOS	Paid	No	(A) (B) (C) (D)	Paid	adobe.com
Adapt Learning	Web (Cloud), Windows, macOS	Free	Yes	(A) (B) (C)	Community	adaptlearning.org
Articulate Rise 360	Web (Cloud)	Paid	No	(A) (C)	Paid	articulate.com
Elucidat	Web (Cloud)	Paid	No	(A) (B) (C)	Paid	elucidat.com
eXeLearning	Windows, macOS, Linux	Free	Yes	(A) (C) (E) (F)	Community	exelearning.net
Gomo Learning	Web (Cloud)	Paid	No	(A) (B) (C)	Paid	gomolearning.com
H5P	Web (Cloud), LMS integrated	Free	Yes	(A) (B) (C) (G)	Community	h5p.org
iSpring Suite	Windows	Paid	No	(A) (B) (C) (H)	Paid	ispringSolutions.com
Lumi	Windows, macOS, Linux	Free	Yes	(A) (B) (C) (G)	Community	lumi.education

SCORM (A); xAPI (B); HTML5 (C); MP4 (D); IMS (E); EPUB (F); H5P (G) PPT (H)

To ensure accessibility for users with varying levels of digital literacy, the LO was designed with clear language and intuitive usability, preventing disparities in user engagement. e-Content development can be carried out using hard-coded programming languages or authoring tools [31], such as those shown in Table 4, with the latter facilitating the creation of engaging and interactive training materials [11] [16] [20]. Initially, eXeLearning [45] was considered due to its extensive library of interactive exercises (iDevices). However, during the integration phase of the e-

Content development cycle, technical constraints emerged, preventing the collection of viewing data in Moodle's SCORM packages. Consequently, the authoring tool Lumi [46] was selected for its ability to create standardized SCORM-compliant (H5P) content. Unlike H5P.org, which only serves as a demonstration platform without export or storage options, Lumi is a standalone application that allows local content creation, editing, and export without requiring an LMS or an internet connection. H5P, an open-source tool integrated with xAPI for tracking learner interactions [46], was chosen based on the IEFP's Continuous Pedagogical Training Framework for Self-Learning e-Content [47]. Its popularity stems from its ability to generate dynamic, responsive, and reusable learning resources without requiring advanced programming skills. Compared to proprietary alternatives such as Articulate Storyline, Adobe Captivate, and iSpring, which offer advanced functionalities but require significant financial investment, H5P provides a free, accessible, and flexible solution for interactive content creation.

Table 5. Comparison of image editing software

Software	Licensing	Open source	AI editing	Operating System / Platform	Official link
Canva	Paid /Free	No	Yes	Web (Cloud), Windows, macOS	canva.com
CorelDRAW	Paid	No	Yes	Windows, macOS	coreldraw.com
Figma	Paid /Free	No	No (A)	Web (Cloud), Windows, macOS	figma.com
GIMP	Free	Yes	No (A)	Windows, macOS, Linux	gimp.org
Illustrator	Pago	No	Yes	Web (Cloud), Windows, macOS	adobe.com
Inkscape	Free	Yes	No	Windows, macOS, Linux	inkscape.org
LibreOffice (Draw)	Free	Yes	No	Windows, macOS, Linux	libreoffice.org
Krita	Free	Yes	Yes	Windows, macOS, Linux	krita.org
Photopea	Free	No	Yes	Web (Cloud), Windows, macOS, Linux	photopea.com
Photoshop	Paid	No	Yes	Web (Cloud), Windows, macOS, mobile devices	adobe.com
Pixlr X/E	Paid /Free	No	Yes	Web (Cloud), Windows, macOS	pixlr.com
Sketch	Paid	No	No (A)	macOS	sketch.com

(A) possible with third-party integrations

To enhance the learning experience, multimedia elements were prioritized, aligning with Digital Storytelling methodologies. Graphic elements for the LO content were created using GIMP (GPLv3 license), with alternative software options outlined in Table 5. The integration of AI-powered graphic editing tools facilitates tasks such as background removal, color adjustments, and design generation from text descriptions, improving accessibility and efficiency. To support Digital Storytelling, a structured storyline was developed to enhance professional and personal knowledge transfer. Videos were produced to reinforce learning through direct experience and reflection, using open-source tools such as Kdenlive (GPLv3 license), incorporating images, video, and voice elements. Alternative software solutions, like the ones in Table 6, were also considered. All videos include subtitles to improve accessibility, ensuring content can be followed via audio or text. The final multimedia compositions adhere to storyboard-defined actions, maintaining narrative coherence across topics 2 to 5 (Figure 1), ensuring a seamless Digital Storytelling implementation.

Table 6. Comparing video editing software

Software	Operating System /Platform	Licensing	Open source	Support	Official link
Premiere Pro	Windows, macOS	Paid	No	Paid	adobe.com
Clipchamp	Web (Cloud), Windows	Paid /Free	No	Paid	clipchamp.com
DaVinci Resolve	Windows, macOS, Linux	Paid /Free	No	Paid	blackmagicdesign.com
Filmora	Windows, macOS	Paid	No	Paid	wondershare.com
Final Cut Pro	macOS	Paid	No	Paid	apple.com
Kapwing	Web (Cloud)	Paid /Free	No	Paid	kapwing.com
Kdenlive	Windows, macOS, Linux	Free	Yes	Community	kdenlive.org
Loom	Web (Cloud), Windows, macOS	Paid /Free	No	Paid	loom.com
OpenShot	Windows, macOS, Linux	Free	Yes	Community	openshot.org
Shotcut	Windows, macOS, Linux	Free	Yes	Community	shotcut.org
WeVideo	Web (Cloud)	Paid	No	Paid	wevideo.com

5 Demonstration of the artefact in the organization

The artefact developed in the previous chapter was implemented as a training course on the INATEL Foundation's LMS. This platform is only accessible within the organization's network via the LDAP protocol with the credentials registered in the organization's centralized database, AD. To ensure methodological transparency and support the study's validity, participants were recruited from within Fundação INATEL, specifically among employees who voluntarily completed the e-learning module developed for the case study. While self-selection bias was considered a potential limitation, efforts were made to include a diverse sample by encouraging participation across multiple departments and geographic locations. For a population of N=1055, the ideal sample size for this study, with a 95% confidence level, a 5% margin of error, and an expected proportion of 50%, is 282. Following the invitation email, 263 employees (24.9% of the total population) accessed the Moodle platform, with 247 enrolling in the course (23.4%), the artefact under study. A study conducted in Portugal [48] indicates that the usual participation rate in non-formal work-related courses is 38.5%, while online course participation is 31.8%.

The estimated total training duration was 37 minutes, considering the length of videos and audio content, and approximately 30 seconds for each assessment question. Among the 247 enrolled employees, 93% initiated the training, with participation rates varying per unit, from 80% (Summary) to 93% (Unit 1.1 – Introduction to GDPR Principles). On average, participants spent 36 minutes and 18 seconds in training, with a median of 35 minutes and 42 seconds, while the minimum and maximum recorded times were 7 minutes and 26 seconds and 1 hour, 22 minutes, and 7 seconds, respectively.

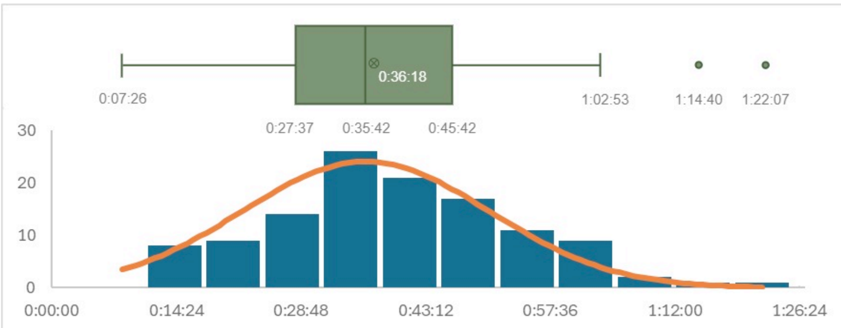

Fig. 2. Statistical analysis of training participation times

Access patterns impacted the training completion rate, as 87% completed it on the same day they enrolled, but only 44% of those who accessed it over multiple days finished. In the summative assessment, 82% assessed the evaluation, but only 48% submitted responses, with scores ranging from 5 to 8 (mean: 6.98, median: 7, standard deviation: 0.71). Notably, Question 7 had the lowest success rate (31%), while other questions had success rates between 83% and 99%. Pearson correlation analysis indicated a moderate positive relationship (0.53–0.60) between time spent on specific units and overall training duration. At the same time, the difficulty of Question 7 was associated with lower overall assessment scores (correlation: 0.51).

6 Validation by satisfaction survey

Questionnaires are widely used to collect user information and opinions, particularly in large and dispersed groups, but as data collection occurs without supervision, questions must be clear and easily understood [49]. The questionnaire should begin with its objective and relevant demographic data, followed by specific questions aligned with the study's goals, avoiding ambiguity or response bias [49]. The questions were designed to gather insights into the acceptance, functionality, and benefits of the e-Content training, ensuring relevance to the research questions. To

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ensure authenticity, the satisfaction survey was integrated into Moodle and made available after the summative assessment.

The survey was designed to align with the research objectives and consisted of two sections: Section I aimed to profile participants by collecting data on their geographic location, gender, educational background, job role, and length of service at INATEL. Section II focused on assessing user satisfaction with microlearning-based training. It explored the perceived relevance of the content, clarity and accessibility of the materials, adequacy of the training duration, and the effectiveness of the structure and sequencing of topics. Particular attention was given to the motivational impact of the Digital Storytelling approach and pedagogical milestones, as well as the extent to which microlearning supported flexible, self-paced learning. The survey also examined whether participants required additional tools, such as AI to understand the content. Open-ended questions gathered qualitative insights on benefits, difficulties encountered, technical issues, and suggestions for improvement.

The survey targeted all employees and 205 valid responses were obtained, detailed in Figure 3. Most participants found the training relevant (93%), clearly presented (99%), appropriately timed (98%), and aided by narratives and examples (98%). The interactive activities were deemed useful (98%), and 99% appreciated the flexible format. Most respondents (92%) reported learning something new, and 89% encountered no difficulties. Only 1% used AI tools for support. Open-ended responses highlighted the training's clarity, accessibility, and flexibility, while suggested improvements included content updates and better assessment questions. Pearson correlation analysis indicated moderate positive relationships between aspects such as training duration, clarity, interactivity, and structure.

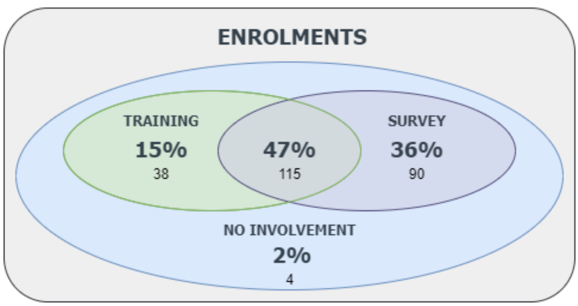

Fig. 3. Venn diagram showing enrolments, training completed, and valid surveys

The analysis identifies a relationship between training completion and survey responses among 247 employees: 36% completed only the survey, 15% completed only the training, and 47% completed both. A Levene's test and t-test confirmed the statistical equivalence of data samples. Pearson correlations indicated moderate relationships, such as usability concerns (Q14, 0.57) linked to multiple test attempts and AI tool usage (Q12, up to 0.57) influenced by unit access frequency. Among the 67 responses to a follow-up question for those who did not complete the training, 75% believed they had finished, 25% cited work constraints, 6% mentioned usability issues, and 2% lacked interest. LMS data showed that 62 employees accessed the assessment but did not complete it, suggesting professional distractions, usability problems, or technical issues as possible causes.

7 Key scientific contributions: Guidelines for the Technological Development of e-Content for Self-Learning

The use of SCORM/xAPI and H5P in the development of microlearning e-Content makes it possible to create interactive and monitorable materials, promoting engaging and effective learning. The model proposed, based on the ADDIE cycle, structures the creation of content for self-learning, guaranteeing flexibility, autonomy, and alignment with the needs of the participants. Using the proposed technological tools, the implementation of this model in educational and organizational contexts will contribute to knowledge retention and learning success.

This reference guide is intended to establish guidelines for the development of microlearning e-Content aimed at self-learning in distance learning environments, where the aim is to guarantee pedagogical effectiveness and the adoption of technologies that benefit your training experience, as illustrated in Figure 4.

The integration of appropriate technological components at each stage of the ADDIE model guarantees the creation of effective, interactive content aligned with learners' professional needs. The adoption of strategies such as Digital Storytelling and continuous assessment contributes to motivation and success in self-learning.

I Fundamental Principles

Short, objective content; Interactivity and continuous feedback; Flexibility and accessibility; Monitoring and analyzing progress; Alignment with professional or educational needs.

II Technology applied to the stages of the Instructional Model (ID)

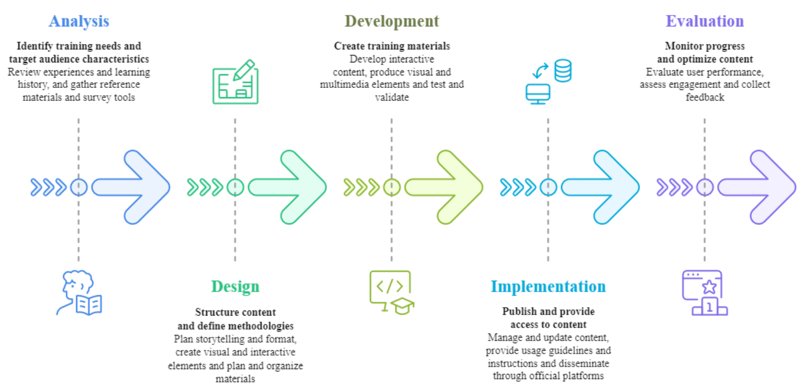

Fig. 4.. Diagram of the Reference Guide for technology applied to the stages of the Instructional Design Model

i) Analysis - *Identifying training needs and characteristics of the target audience*
Identifying profiles and learning history: analyzing pre-existing data in an LMS and LRS; Survey needs with survey tools: Microsoft Forms, SurveyMonkey, or LimeSurvey.

ii) Design - *Structuring content and defining methodologies*
Planning the training structure: Storyboarding tools, using one of the software identified in Table 2; Creation of visual elements: Graphic design software, in which it is proposed to use one or more of the software identified in Table 5 at the same time; Organization and interoperability of materials: LOs developed with xAPI (e.g., H5P).

iii) Development - *Creating training materials*
Developing interactive content with authoring tools: Lumi, or as an alternative proposal, another tool identified in Table 4; Producing videos, audio, and other multimedia elements: video editing tools proposed in Table 6; audio editing: Audacity or Adobe Audition; graphic design tools proposed in Table 5.

iv) Implementation - *Publishing and making content available*
Making content available and managing it: Moodle or another LMS identified in Table 3; Integration and tracking to analyze behavior patterns and difficulties: xAPI with H5P, data collection with an LRS. Summative assessment: integrated directly into the LMS or developed using authoring tools, Table 4.

v) Assessment - *Monitoring progress and optimizing content*
Analyzing user performance: LMS and LRS dashboards; Evaluation of the environment with survey tools: Microsoft Forms, SurveyMonkey, LimeSurvey, or in the LMS itself.

8 Research conclusions and preliminary answers to the RQ

The application of the DSR methodology enabled the development of an artefact specifically designed to address a real-world problem. This research was underpinned by an SLR conducted according to Barbara Kitchenham's protocol, which yielded 22 pertinent articles from the Ebsco, Scopus, and Web of Science databases. The SLR rigorously identified opportunities in the state-of-the-art, defining the parameters for the artefact's design, practical relevance, and evaluation while also revealing a convergence between the initial research objectives, the investigation outcomes, and their theoretical and practical implications. Furthermore, the review confirmed that microlearning is an established, efficient, and ubiquitous solution in organizational training, with Digital Storytelling emerging as a complementary method that enhances learner engagement despite the dichotomy presented by technologies such as SCORM, xAPI, and LMS, which, although standardizing content creation, may be perceived as complex due to technical jargon and limited user experience.

Preliminary findings addressed several research questions. RQ1 demonstrated that microlearning benefits professional training by offering focused content, immediate feedback, and increased learner autonomy, thereby consolidating specific knowledge and suggesting potential broader applications within organizations. RQ2 indicated that the use of SCORM and its successor xAPI in the Digital Storytelling methodology enables rapid design and implementation of multimedia content, with tools like Lumi overcoming technical limitations to ensure standardization and interactivity. Meanwhile, RQ3 identified that both organizational and individual factors, such as content relevance, technological familiarity, and practical constraints, significantly influence the adoption and efficacy of microlearning. RQ4 findings highlighted that positive perceptions of interactive, formative assessments foster motivation, satisfaction, and performance, even though usability challenges in self-assessment may hinder these benefits.

8.1 Future and Further Work

Based on the identified results and limitations, several future work approaches are proposed to enhance and deepen this research. One key area is conducting load tests on the developed artefact by directly observing user behavior, which will help identify technical or usability issues and improve the overall experience. In addition, the Delphi research methodology consulting experts will be adopted to refine and validate the design and functionality of the training artefacts suggested. Other priorities include enhancing automated assessment and feedback in self-directed learning to provide more accurate and relevant evaluations, diversifying training topics to increase impact (potentially validated through a randomized controlled trial (RCT)), and exploring strategies to ensure that e-Learning aligns with universal design principles for improved accessibility. The integration of advanced technologies such as AI, adaptive learning, and chatbots into personalized learning platforms, combined with learning analytics (via LSR) and performance prediction, is also recommended, along with investigating methods to visualize and interpret xAPI data within Moodle using advanced analytical dashboards. Furthermore, it is important to integrate such training into the official organizational development plan, in line with the CNQ of ANQEP and/or ESCO, thereby facilitating effective learning pathways through certified e-Contents, using metadata to organize LO based on competency units and ensuring formal recognition of acquired competencies via methodologies such as RVCC.

In light of the study developed through the SLR, future or complementary investigations could address the following research questions: a) How can automated feedback, supported by AI algorithms, be implemented to provide real-time, personalized assessments that either replace or complement the trainer's role? b) How are the SCORM and xAPI standards evolving to support emerging technologies (augmented/virtual reality, AI), and what gaps exist in their capacity for integration? c) In what ways can emerging technologies such as AI, machine learning, and virtual or augmented reality be integrated into e-Learning environments to enhance personalization, feedback, and the overall training experience? d) What technical challenges are encountered in the collection, analysis, and interpretation of big data generated by e-Learning processes to enable real-time improvements? e) What security and privacy issues arise from implementing e-Learning with xAPI for real-time AI interactions? and f) What are the technological challenges in ensuring the usability of e-Learning platforms for users with varying levels of digital literacy, and how can these be overcome through innovative design and interface approaches?

CRediT author statement

Duarte Dionísio: Conceptualization, Methodology, Investigation, Software, Data curation, Formal analysis, Visualization, Writing – original draft. **Arnaldo Santos:** Supervision, Conceptualization, Methodology, Writing – review & editing, Project administration.

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