

Designing a New Generation of Learning Management Systems

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Abstract—This paper focuses on the architecture of a Learning Management System (LMS), and how to redesign it to facilitate and increase its usage inside an information system and achieve a more profound and better integration. By expanding the functionality of LMSs beyond the traditional educational setting, organizations can benefit from a centralized system that can handle a wide range of tasks. This can include project management, decision-making support, collaboration services, calendar management, bidding management, multi-point collaboration, document co-writing, etc. However, integrating these additional functionalities into an LMS can be challenging. It requires a deep redesign of the software architecture and understanding how these functionalities can be best implemented within the system. LMSs can be a powerful tool for organizations to manage various tasks other than purely educational tasks, thus improving efficiency and reducing the need for separate systems.

Keywords—e-learning, LMS, architecture, virtual communities, semantic technologies

I. INTRODUCTION

Learning Management Systems (LMSs) are modern software platforms that support almost any educational need, bringing their services a high level of maturity. Since the end of the last century, software solutions like Blackboard™ and WebCT™ provided proper support to training and teaching tasks. Even if it is clear to everyone, after the pandemic, that e-learning services and tools will be unavoidable elements of educational processes, on the other side, the integration of these tools with the rest of the Information System of any institution is very weak, if not inexistent. Accordingly, they never really entered the organization's Information system, remaining as an isolated solution, loosely coupled with the rest of the services provided to the users. Indeed, LMS's market share and application field have not taken the market by storm, even if most of the services provided (file sharing, discussion forums, and questionnaires, to mention a few) are needed inside the company and are provided by other platforms.

With quicker network backbones and the pandemic pushing towards videoconferencing systems, LMSs' role and market share have been occupied by tools conceived initially for other purposes, mainly collaboration tools with no specificity for educational processes. Even the availability of Free, Open-Source Software (FOSS) like Moodle did not take LMS's services and pedagogical approaches out of the shadow created by large, multi-functional solutions like Microsoft Teams™, Zoom™, or other similar solutions. Recently these software solutions also took advantage of the many positive aspects of cloud computing, solving the traditional issue of on-premises platforms: maintenance costs, hardware and software costs, technical personnel, scalability, support, etc. Another category of LMSs occupies a niche in the educational world, i.e., the so-called “closed” or “proprietary” solutions. These are solutions created from scratch specifically for educational purposes, sometimes deriving from customizations of open source LMSs, or customization of other software platforms created for other purposes “forced” to become technology-enhanced learning environments. Customizations created over Content Management Systems (CMS) are the most evident examples: WordPress™, Drupal™, and Joomla™ are notable examples.

An LMS is a complex web platform that should live inside an information system, providing services to a specific group of users. LMSs, especially with the level of services added during the pandemic, provide robust services that can be used in any context related to an electronic collaboration among participants and are not only limited to pure educational purposes. Besides this vast potential of service providers, LMSs are seen mainly by institutions and ICT departments as a separate world. Most of the time, some single-sign-on services allow integrating the LMS with the rest of the information system, so users can use the same credentials for other applications, but not much more than this. Its presence inside the organization creates an evident duplication of services inside the Information Systems, increased costs, and confusion among the end-users.

This paper explores the architecture of a new generation of LMSs, more collaborative and more integrated with the rest of the Information System of the hosting organization, thus becoming a centralized

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provider of collaboration services for its users. Two main research lines of a long-term project are shortly presented here: a) how to intervene in an LMS's architecture to create a more generalized, collaborative environment devoted to support collaboration tasks and not only educational ones; b) how to facilitate the integration of these newly-conceived LMSs into corporate information systems, thus avoiding duplication of services for end-users and improving their Total Cost of Ownership (TCO).

During this long-term research, seven service classes have been developed as extensions of a self-developed LMS. This LMS is based on the "virtual community" metaphor, a container of activities made online by its members. The funding principle is that educational tasks are just a subset of collaboration activities. Accordingly, providing collaboration services inside an LMS could enhance learning performance and allow an LMS to be used in collaboration contexts. Our experimentation's results evidence that this integration and a much broader application of LMSs could be achieved by profoundly redesigning their logical and software architecture, which is nowadays heavily conditioned by educational concepts like "teacher", "student", "classroom", "lecture", etc. This paper provides insights into the internal architectural changes of this self-developed LMS, the resulting new services, and how these changes can facilitate the integration of the new LMS design into an organization's information system stack. The platform has been successfully adopted by public and private organizations and has enabled fundraising activities, leading to the creation of a spin-off company for commercialization. The paper is organized as follows: chapter two deals with the issue of integrating LMS into the hosting Information System, an essential aspect for adopting LMSs inside organizations. Chapter three details the focus of the research, while chapter four presents further details of one category of new services that have been created.

II. LMSs AND THEIR INTEGRATION WITH THE INFORMATION SYSTEM

The importance of education in organizations has become increasingly crucial for several reasons. Firstly, organizations are now aware of the need for lifelong learning processes, a fundamental aspect of any organization [1]. With today's workers being inundated with vast amounts of information, it has become essential for them to learn far more than any individual can retain. Lifelong learning is not a luxury but a fundamental challenge for organizations [2]. This challenge encompasses several new dimensions of learning, such as self-paced learning, on-the-job training, collaborative learning, continuous learning, organizational learning, and learning by doing.

Unfortunately, the pandemic has highlighted the second reason education is central to modern organizations. Organizations have realized the importance of good software platforms to support collaborative processes, including education-related ones. As a result of these and other relevant factors,

information system managers face a typical dilemma of modern organizations when needing to automate processes. This dilemma involves deciding how to address educational needs using a software platform, and there are several options to consider, including:

- Acquiring a new software solution or service
- Leasing an existing solution or service
- Adapting an existing software solution
- Creating a new solution from scratch

New alternatives such as service outsourcing and cloud solutions further enrich these options.

The aim of this paper is to provide insights into how organizations can address the dilemma of addressing their educational needs through software platforms. Specifically, this will be achieved by identifying the limitations of current LMSs that can be acquired or leased and by guiding how to adapt existing platforms or create new ones from scratch, to extend the use of LMSs within an organization. Therefore, this research sits at the intersection of two different areas: software engineering for information systems, which is concerned with providing effective and efficient software solutions (on-premises, SaaS, or cloud) to meet organizational needs, and technology-enhanced learning, which involves using technology to optimize the learning experience within organizations.

Our attention focuses on software solutions designed for LMSs, an area where two research frameworks overlap. The research investigates the re-engineering and extension of services provided by LMSs to enhance their role in the ICT strategy of organizations. This paradigm shift involves changing the foundational pillars of LMS design and implementation to provide more collaborative and cooperative services and integrate them better with the rest of the information system. The aim is to move LMSs from a marginal, accessory role to a central position in organizations. The research explores changes in the educational aspects and technical solutions provided by LMSs, which could be useful for IT managers in optimizing investments and maximizing software platform usage [3]. Although the research is focused on LMSs, the findings may also be relevant to the information systems field.

In addition to its focus on LMSs, this research also aims to address the issue of "e-learning disillusionment," which interests academic and business communities. The widespread underutilization of e-learning tools, relegated as document-sharing tools and contact hubs for course participants, has contributed to this disillusionment. Despite the pandemic providing an opportunity to celebrate e-learning tools as indispensable for organizations, the opposite has happened. Instead, there has been a focus on videoconference tools as the sole solution for e-learning, with trivial educational services added to these platforms. As a result, LMSs have been marginalized because their rich set of features are considered too complicated and unnecessary, and most of all, partially if not fully, overlapped with similar tools provided by design by the organization's information system. This research seeks to dismantle this

disillusionment and promote the importance and value of LMSs for organizations.

The interests outlined earlier can lead to numerous possible extensions of educational services. This research delves into four specific areas of analysis, design, implementation, and testing for the evolution of a modern LMS. These areas of research/intervention begin from the bottom layer of the platform, which includes the concepts that are typically implemented in every software layer, and move upwards towards the services offered to end-users. The upper layers benefit from the re-engineering process in the lower areas. Fig. 1 displays the four areas of revisitation/evolution of an LMS explored in this research work. The papers within this research have a primary, non-exclusive central topic within the four areas.

The focus of the Conceptual area is to broaden the core concepts of an LMS beyond a simple “course” container to a more comprehensive “community” container that can manage different types of communities with various aims. This paradigm shift represents a significant innovation in the services the LMS provides, requiring a complete overhaul of the platform and a fundamental re-engineering of the services provided, data stored, and user interface metaphors and proposals. Researchers’ past work has been the primary inspiration for this area of investigation. Nevertheless, the founding pillar of “virtual community” instead of “class” has been implemented, and it has been revealed to be a winning factor for the evolution of LMSs.

The second area of investigation, the “Foundational area”, focuses on the persistence layer of an LMS. One

aspect of this research is the exploration of adding artificial intelligence extensions to LMS services to enable a richer representation of learning content and a conceptual description of the domain. However, representing this rich knowledge base inside the LMS relational database is challenging due to the semantic limitations of the relational model. A more semantic-oriented representation of concepts was explored to overcome this limitation, moving from a relational model to an ontological one. This approach allows the application to be closer to supervised and unsupervised machine learning applied to such a rich knowledge base.

Another consequence of this second area of investigation is managing big data in an LMS context. New approaches, such as adopting distributed databases, new data processing techniques, distributed computing and cloud-based solutions, are needed. Integrating these technologies could enable LMSs to collect, analyze, and make sense of the large amounts of data generated by learners and instructors, leading to more personalized and adaptive learning experiences. This research front aims to investigate and propose solutions to enable LMSs to handle big data effectively while ensuring data privacy and security. The context being discussed relates to big data from any perspective of the three V’s definition in the big data sector, namely “Volume”, “Variety”, and “Velocity”. LMSs are not currently conceptually or technically equipped to handle this situation despite this. Managing big data within the context of an LMS requires intensive processing and involves handling large volumes of data.

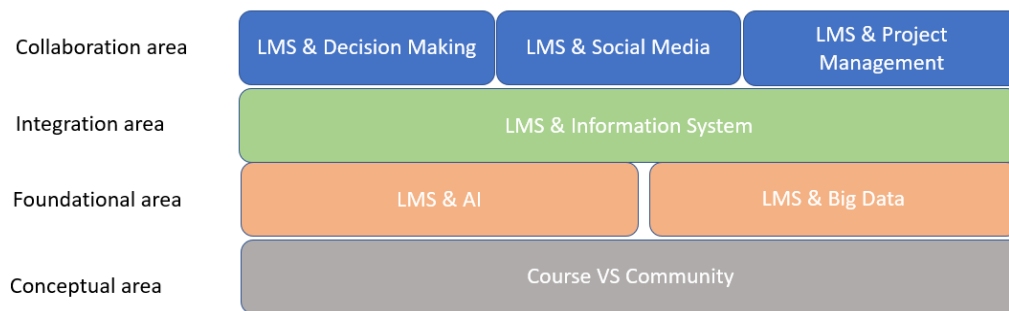


Fig. 1. The focus of this research: four areas of evolution for an LMS with seven foci.

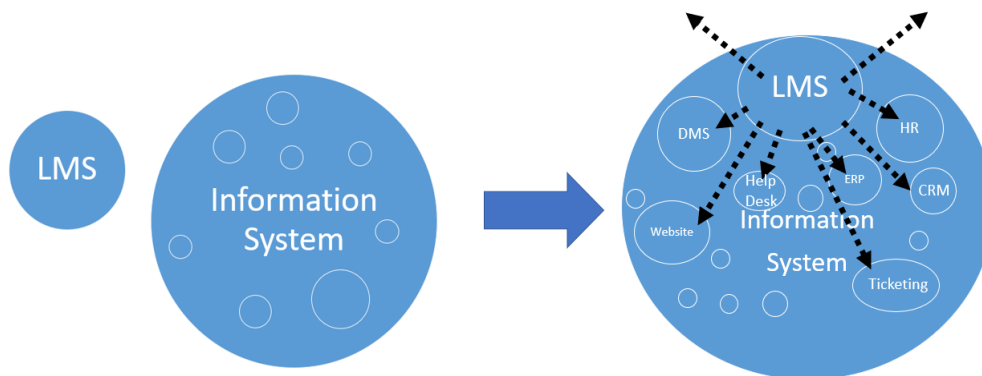


Fig. 2. From an LMS functioning as a standalone entity to incorporating its services with other components of the information system.

The third area of investigation pertains to the “Integration area”, which entails integrating LMSs with other information systems in an organization. This integration provides top-notch services, optimizing ICT investments. When implemented in an organization, LMSs have an immediate impact, necessitating integration with other existing sub-systems, ranging from simple single-sign-on authentication and authorization to more complex integration processes with ERP, CRM, and HR systems. Moreover, LMS functionalities may overlap with pre-existing functionalities in the organization’s information system, such as document repository, mailing distribution, virtual room management, forums, etc., which raises concerns regarding duplication or omission of these functionalities. Additionally, LMSs may compete with social media services obtained by the organization due to the availability of similar features in LMSs. The most deceptive aspects arise as none of the systems, whether LMS or other information systems, can cater to the specific requirements of educational stakeholders.

Nonetheless, each system can provide some of the functionalities that are needed. A classic illustration of this is support for effortless document sharing. In several instances of integration gathered over the years, the educational-based concepts and tools used in an LMS are generally not conducive to comprehensive and satisfactory integration, leading the IT department to devise workarounds or discard the LMS altogether. An LMS founded on virtual communities is a far more suitable option. A virtual community offering various services to its members is a viable solution for addressing a range of challenges, including educational activities. Fig. 2 illustrates the expected relationship progression between the LMS and the information system. The integration of new collaborative services, as shown in the following section, with e-learning platforms and their integration into the hosting information system presents a challenge in developing advanced e-learning platforms. Instead of treating LMSs as independent units in the hosting information system, our research suggests that the seamless integration of these components can benefit the entire organization.

The last focal area explored in this research is the “Collaboration area” of expansion for LMSs, which aims to offer collaboration services to users. Within this area, there are three main lines of study: developing new services to improve integration with social media platforms, creating decision-making support services within LMSs, and researching how to integrate project management tools into LMSs. The evolution of LMSs in collaboration has been noteworthy, particularly after the surge in social media usage among students. This trend has sent a clear message to LMS creators to incorporate social media-like features into their platforms to enhance user collaboration in a more user-friendly, socially-oriented manner. The created platform explored and provided multi-criteria and multi-expert decision-making tools to support various stages in the life cycle of a virtual community, where decisions must be made, ranging from evaluating students to announcing the winner of a public

competition. This expansion has very few (if any) examples in a learning environment. The most significant advantage of the developed services is that the organization can use these “collaboration” situations without purchasing or adopting another information system.

One significant example of adopting these tools has been creating a collaboration service for managing public competition notices, loading applications, managing evaluation commissions, and publishing competition results. Additionally, we have experimented with project management-enabled services, which allow users to manage tasks with the characteristics and needs of a project using professional tools. The evolution towards a collaborative environment is natural for e-learning, given the nature of learning processes and the tools needed in every work environment. While LMSs have been widely used for managing and operating e-learning courses, they offer minimal support for tasks not strictly related to the classroom metaphor. The educational metaphors used in structuring current LMSs, such as “teacher”, “class”, “grade”, and “lecture”, do not support this evolution, and many other functionalities and features unrelated to educational aspects should be added.

IT managers face two main concerns regarding functionalities not available in an LMS, such as student enrollment, public tenders and concourses management, and support for group decision-making or project management tasks. The first concern is the availability of the same functionalities, which can lead to problems justifying the budget or deciding which system to remove. The second concern is the integration of different systems, which can result in higher development and maintenance costs.

The process of analyzing the different implementations of the research areas involved a) focusing on existing software with similar tools and services, b) understanding how they work and what they provide to users, and then c) creating new services in the LMS using different conceptual and foundational structures while providing integration mechanisms for the rest of the information system when relevant. This process took a long time and involved collaboration with a research group active since 1998, consisting of about 50 people who have collaborated in different roles over the years.

III. RESEARCH FOCUS AND LITERATURE REVIEW

In more technical detail, we have investigated a radical change in the foundational pillars of LMS platforms that could positively impact their role and diffusion. The research has concentrated on seven foci related to specific problems within the four research areas previously introduced. However, many other research directions in e-learning can be explored, including the effectiveness of e-learning inside organizations, new models of delivering e-learning, serious games, mobile devices in educational contexts, course design issues, and measuring e-learning effectiveness. The seven foci of this long-term research concentrate on the context of the future evolution of LMSs are:

- LMSs and the course vs. community dilemma
- LMSs and the integration with the rest of the information system
- LMSs and social media services
- LMSs and decision-making tools
- LMSs and artificial intelligence tools and techniques
- LMSs and big data
- LMSs and project management services

The selection of these research foci is based on the changing needs of users, advancements in tools and techniques from other fields that could be applied to e-learning, and emerging phenomena that may impact e-learning. These foci share several common characteristics: they have the potential to improve educational processes, they aim to enhance collaboration within virtual communities, they could represent an innovative addition to LMSs, and they are not currently available in existing LMSs. This section reviews relevant literature related to each focal area.

The common elements to these research areas include their potential to enhance educational processes, improve collaboration in virtual communities, and serve as relevant innovations for software platforms like LMSs. The central issue is identifying duplication and integration problems when incorporating LMSs into the services offered to stakeholders. The problem lies in the core architectural concepts of LMSs, which are based on education-related concepts like “class”, “course”, “student”, and “teacher”. These concepts are not suitable for collaborative settings outside of education, such as research groups, recreational communities, or labor union associations. These concepts relate strictly to education, thus preventing LMSs from being used in a conceptually native way outside these contexts.

We, therefore, propose a redesign of LMS architecture around the concept of a “virtual community” to solve and improve the possibilities for LMSs to become central within modern information systems. It represents a radical change to the internal architecture of an LMS, from the design of classes used in the code to the services provided to the end user. The proposed new category of software platforms is referred to as “Virtual Community Management Systems” or “Community Management Systems”, where various services oriented towards education, communication, collaboration, multimedia management, videoconferencing, file sharing, project management, support to decision processes, time management, and lifelong learning services are provided. We promote a new approach to developing e-learning platforms instead of modifying existing ones, which have already been widely adopted and used by millions of users worldwide.

The proposed approach is to create a new generation of e-learning platforms from scratch, using metaphors that are more focused on collaboration rather than just education for the software components of the platform. Instead of thinking of an LMS as a container for educational tasks, the proposed approach would generalize these tasks as more broadly focused

collaboration tasks and abstract the concepts inside the platform accordingly. By doing so, it would be possible to create a single platform that could be used in both educational and other collaborative contexts, which would be more easily integrated into the information system of the hosting organization.

To bring about this shift in design, a new metaphor must be adopted for building software platforms. The foundational elements of this new generation of platforms are virtual communities, which expand upon Rheingold’s concept of virtual meeting places [4], where IT services are used for various collaboration purposes, including education. As a result, the platform becomes complex, demanding, and potentially costly in terms of Total Cost of Ownership (TCO), but it can accommodate a wide range of needs beyond just training. Typically, companies allocate minimal budgets for IT investments in e-learning [5, 6], despite their extensive training needs. Consequently, implementing a dedicated LMS would encounter significant obstacles within a typical IT budget. When e-learning is approved, it is often viewed solely as a cost-saving instrument rather than as a flexible tool to empower the workforce and achieve training goals.

A virtual collaboration platform would provide internal, multi-purpose, and extensible services that information system managers could utilize for various needs, including education. Our research involved evaluating how virtual collaboration and communities could enhance the integration and adoption of online learning in modern organizational systems by examining the structure of commonly used learning platforms, both open and proprietary. This evaluation included a detailed analysis of LMS technology, to which we added more collaboration-focused tools and utilized them as a container for collaboration processes. Based on these beliefs, the team decided to develop a new virtual community platform called “Online Communities” (OLC), which was designed from scratch without any influence from existing LMSs.

The platform was built around the metaphor of virtual communities and was not solely focused on educational services. This approach had two positive outcomes: first, users appreciated the platform’s usability in various settings, and secondly, new collaboration services were added, which were also beneficial for learning contexts. The platform’s original kernel, which was created in 1998 to address collaboration and integration needs during a time when social networks did not exist, was intended to be fully integrated with the hosting information system of educational institutions. OLC has been implemented in numerous academic and non-academic environments and is currently used by over 250,000 users in the public sector, as well as the insurance, finance, and education industries. It has provided services to both traditional educational providers and collaboration services, resulting in optimization and the avoidance of redundancies.

The potential to use the platform beyond educational settings for various community needs, has greatly impacted the platform’s Total Cost of Ownership (TCO).

To achieve this, the design must prioritize the platform's integration with the hosting organization's information system with minimal impact. Traditional e-learning platforms have limitations in their extensibility and usability outside educational contexts. Platforms with a collaboration-oriented approach have demonstrated higher flexibility in adapting to diverse situations where users need a technological collaboration tool. Content Management Systems (CMSs) and Document Management Systems (DMSs) have been utilized in place of Learning Management Systems (LMSs). For instance, tools such as Joomla®, Wordpress®, and Drupal® have been adapted for educational purposes, and some individual teachers have created private websites using these tools due to insufficient institutional support. Facebook™ and social media in general have also played a role in substituting e-learning services due to its robust collaboration services, and some teachers have even created Facebook™ pages for their students to utilize these services.

Exploring the platform's persistence layer, where data is stored, is another promising area for investigation in this paradigm shift. Significant innovations in the representation of educational processes were made possible through long-term experimentation with users and access to the complete source code of OLC. The platform was built from scratch by over 50 people, including full-stack developers, UX experts, psychologists, and software architects, who have been working together since 1998. With over 20 years of experience in different contexts, it is clear that learning platforms contain a vast amount of knowledge, represented by teaching materials with multimedia elements and all the interactions between teachers and learners in various blogs, chats, and forums.

Ontological and semantic representations of the domain offer a more expressive and flexible way of representing knowledge than relational data models' rigid structure. Ontologies provide a standardized vocabulary and relationships for representing knowledge, allowing for easier integration and interoperability between different systems. On the other hand, NoSQL databases offer more scalability and performance for handling large volumes of data, making them attractive for big data applications. In the context of learning management systems, non-relational persistence layers can provide more efficient storage and retrieval of learning materials and more sophisticated search and recommendation capabilities. For example, an ontology-based representation of a learning domain can allow for more intelligent retrieval of learning resources based on their relevance to a specific learning objective or user profile. NoSQL databases can also offer faster access to large amounts of data, which is important for handling online education's growing volume of learning data. Overall, the use of ontologies and NoSQL databases in the persistence layer of learning management systems represents a promising area of research and development for improving the effectiveness and efficiency of online education.

Experimenting with ontologies and graph representation for academic knowledge representation has provided a unique approach to representing entities in the learning platform [7]. This approach supports the reconciliation of entities present in the knowledge base. This experimentation is a frontier for further research, as it is almost unique in the panorama of large-scale learning solutions. This innovation has provided some reflection points on extending the learning platforms to managing the corporate knowledge base and facilitating communication and collaboration services in corporate information systems. This new frontier of evolution and the enlargement of the field of applications for LMSs inside corporate information systems could benefit the LMS market and technology-enhanced learning [8].

IV. DISCUSSION: COURSES VS COMMUNITIES

The most important research focus in the previously presented list is the concept of a virtual community. We want to explore the idea of virtual community as a suitable substitute for a "course" as a foundational pillar for LMSs, thus expanding the use of LMSs beyond purely educational settings. "Virtual community" is used frequently in different contexts, and only recently became common in education mainly because of the contamination of social network usage inside e-learning context. Some definitions of virtual community are so broad that they refer to any group of people whose communication is mediated by ICT [9–13]. Due to this lack of definition precision, we might argue that using the term for any online group can lead to the loss of real meaning for the concept [14].

Rheingold's definition of Virtual Communities (VCs) as an emerging social phenomenon further supports our proposal to re-engineer the LMS. Jones' perspective on the technological structure of VCs (referred to as virtual settlements) has also influenced the definition used in our research [15, 16]. Jones proposes that researchers should distinguish between the technology used by virtual groups and the actual virtual community. He suggests that the virtual settlement, which is the virtual place where people interact, should be considered first. To understand virtual communities, we should understand the artifacts of the virtual settlement, such as postings, structure, and content, similar to how an archaeologist understands a village by examining cultural artifacts. A virtual settlement is considered to exist when there is a minimal number of public interactions with various communicators and a minimal level of sustained membership over time. This framework for understanding virtual communities also recognizes that virtual communities and settlements are conceptually separate but interconnected. If a virtual settlement exists, we can find a virtual community within it. The authors of [17] have further developed this framework by focusing on the feelings and social relationships that develop within virtual settlements. They argue that a sense of community is an essential characteristic of virtual communities and that this sense of community is created by the

psychological connections that develop among participants.

While virtual settlements are necessary, they are insufficient for creating a virtual community. The sense of community sets virtual communities apart from mere virtual groups. After examining characteristics of the sense of community in research by other scholars, we were inspired to consider virtual community platforms as ideal environments for educational processes beyond just community processes. The sense of community is characterized by belonging, influence, integration, fulfillment of needs, and shared emotional connections. Based on these inspirations, we decided to re-engineer our previous learning management system by removing all references to educational communities and artifacts and replacing them with concepts and artifacts that support the creation and management of virtual communities in a life-long perspective. Our implementation of the virtual community closely aligns with the definition commonly used in Web 2.0 contexts. With the advent of modern technologies and the ubiquitous Internet, educators have increasingly sought to create collaborative spaces that engage, motivate, and stimulate students rather than simply transfer knowledge to them. These collaborative spaces have evolved to become virtual as opposed to real.

Playing all possible roles in constructing the new platform has allowed for a thorough understanding of the issues related to the radical change in the LMS and TEL's role in educational processes. As designers, we had complete freedom in constructing the technological infrastructure of the platform without external influences. As software architects and developers, they could contribute their expertise to developing the software components. As power users, mainly as teachers and administrators of communities with different core activities, they were able to understand the needs and requirements of different user groups. Finally, system administrators could create, modify, and analyze any service inside the platform. This comprehensive experience and knowledge have been invaluable in developing the new platform and have allowed the team to make informed decisions.

In certain fields, such as health and social care, professionals have become accustomed to using Virtual Communities of Practice (VCoPs) for various purposes, including learning, support, continuing education, knowledge management, and information sharing. Implementation of virtual communities in educational settings has also shown that these communities can enhance student learning, although they may not be the only mechanism for doing so. Virtual communities offer several benefits, including promoting continued learning and fostering a sense of camaraderie and identity when sustained over time. However, developing an active and thriving virtual community requires careful planning, and the use of collaborative technologies alone does not guarantee success. The COVID-19 pandemic has highlighted the importance of this aspect, as the sense of belonging to a community is typically derived from

regular face-to-face interactions and cannot be replaced by videoconferencing alone. This situation has also created serious issues such as student retention, digital accessibility, and the hybridization of physical and virtual realities. The best solution in these situations is to adopt a blended approach to managing virtual communities. Additionally, confining educational tasks within the "course" container of an LMS does not allow for genuine connections to be made. In educational settings, participants often experience a profound sense of belonging and connection to their peers when the community is open to tasks beyond education. Furthermore, online communities can alleviate the sense of isolation that is often felt in traditional "distance learning" classrooms [18].

The refactoring project was initiated in 2003 and saw its first significant implementation in the "Elle3-lifelong learning" project in 2007. This project spanned over a decade, coinciding with the initial phases of development. It provided a unique opportunity to assess the feasibility of distance learning and virtual communities in educational contexts, particularly in the public sector. "Elle3" was instrumental in shaping the evolution of the Italian public administration towards Technology-Enhanced Learning (TEL). This groundbreaking e-learning experimentation was supported by a brand-new, non-commercial LMS, which was developed from scratch. This uniqueness is due to:

- (1) The number of subjects involved (more than 5,000 users);
- (2) The temporal extension of the project;
- (3) The topics faced during distance learning sessions;
- (4) The involvement of the organization in all the distance learning activities.

During the refactoring process, the LMS's foundational elements were replaced with virtual communities, artifacts, and concepts, as previously explained, resulting in an entirely new conceptual framework. Instead of relying on limited concepts like "classroom", "teacher", or "course", new concepts were introduced to encourage collaboration on the platform. This was achieved by extensively implementing virtual communities as a container for activities and collaboration. In educational institutions, a community has a similar concept, such as the "course" or "classroom". While courses are the primary type of community used in education, other types exist, such as those related to common learning paths, groups of people with a shared interest, or administrative communities like the teaching staff, principal's secretariat, or a working group on a new educational project. As a result, the platform's services are linked to learning objectives and collaboration services.

V. CONCLUSION

This paper discusses a long-term research project aimed at redefining the characteristics of an LMS by facilitating its integration into corporate information systems and creating a more generalized, collaborative environment beyond educational settings. The paper

highlights the challenges faced in this project, particularly the limitations imposed by the foundational metaphor of LMSs, which are based on education-related concepts. The paper proposes redefining the architecture of LMSs around the “virtual community” concept to address these limitations. The project involved technical development and required stimulating users to use LMSs in different contexts and interactions. The paper acknowledges the emergence of new phenomena and competitors in the field of educational technologies. It emphasizes the importance of considering the centrality of technology in human life for researchers, instructors, and ICT managers. Overall, this research project demonstrates the potential for LMSs to become central in modern information systems and highlights the need for continued innovation in educational technologies.

Further research is needed in different directions. Substantially, all the areas we highlighted need a deeper implementation because of their current nature of early implementation, proofs-of-concept, or minimum-viable-products. We have reached a customer-ready level, but the addition of services, the achievement of integration with the information system, and the removal of service duplications at the moment demonstrate the success of the approach, not the reach of an off-the-shelf platform. The value of this long-term research is, in our opinion, elsewhere. It is proof that LMSs as they are today, risk being swept away by a plethora of much more robust and attractive communication tools that do not provide any specific support for educational processes but are very well integrated into the information system. In our opinion, this could even be a reason for the presence or not of LMSs on the market, which at that point will not have reason to exist except in niches where the information system does not provide the basic services.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Andrea Molinari contributed with the technical part of the paper, while Elena Molinari contributed to the UX and the revision of the paper. All authors had approved the final version.

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