A Platform To Communicate Knowledge: K-COM

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Abstract

This article introduces the K-COM (Knowledge COMmunication) system, a web portal for knowledge management and effective communication, that has been developed as part of the italian ES-PA (Energy and Sustainability for Public Administration) project. The platform organises the set of information into Knowledge Objects (KO) within specific Knowledge Pathways (KP) regarding energy efficiency issues. A KO is a resource of a different type (audio, video, textual) placed within a specific KP and identified by an information card (Card). In particular, the application is focused on on-the-job support to Public Administration (PA) users in the field of energy efficiency. The system enables bi-directional communication with a diverse and ever-changing user base. The user categories are government decision-makers, stakeholders and technical and administrative staff employed in public and private sectors. The platform has been populated with gold resources and its usability has been successfully validated with usability tests.

Keywords

Knowledge Communication, On-the-Job Training, Digital Library, Human-Computer Interaction.

1. Introduction

The K-COM (Knowledge COMmunication) platform[1] [1], has been developed by ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development) in the framework of ES-PA project (Energy and Sustainability for Public Administration) aiming to strengthen the technical and administrative skills in public energy-environmental investment programs.

The platform design took advantage of the ENEA's extensive experience in developing energy-related platforms [2, 3], leveraged relationships with national experts and capitalised on the vast amount of reliable sources of energy-related information.

The system manages and analyses data and information related to the energy efficiency sector and energy technologies. This knowledge can become a powerful tool for achieving extremely challenging objectives such as those identified at the European level with time horizons to 2030 and 2050 (respectively, 55% reduction of emissions by 2030 and free carbon society by 2050). Furthermore, K-COM allows knowledge transfer from the research sector to Public Administration (PA) and stakeholders.

[1]URL: https://www.kcom.enea.it

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Specifically, K-COM is focused on On-the-Job Training (OJT) providing digital support to PA users in the energy efficiency field. The main request is to disseminate technical know-how to make decision-makers and administrative staff experts in this sector.

Integrating digital technologies can enhance knowledge sharing within and across communities of people and organisations with similar interests and needs and decision-making processes, leading to improved job performance in distributed work environments [4], [5]. Digital tools can facilitate effective communication and collaboration, enabling teams to collaborate despite geographic barriers.

K-COM is a new interfacing module of the ENEA-MATRIX VI generation platform [6], which is the evolution of the e-learning system deployed by ENEA. Since the 2000s, the Agency has developed learning platforms to encourage the dissemination of scientific knowledge, research outcomes, and to support technical know-how training [7]. The ENEA e-learning approach is based on providing a flexible system with small learning objects that meet just-in-time training user needs.

The K-COM communication strategy is based on the design of knowledge paths (KP) focusing on specific technological and cultural themes to transfer information to recipients proactively and interactively. Each of these paths may contain resources called knowledge objects (KO). Thus, the communication system is fast, efficient, and engaging, without sharing useless information.

The system immediately offers users the needed information, leading them in the knowledge pathway through a few simple steps. Indeed, each KO is visually represented by a Card, a graphical interface element aggregating resources linked to the same subject. So, a Card facilitates managing, querying and viewing information related to a specific resource. The user can modify or delete the resource contents through the Card. This feature makes bi-directional knowledge communication through the platform.

The platform is a dynamic tool designed to evolve continually, especially regarding objects and knowledge paths. Indeed, they could become quickly obsolete; for this reason, they need frequent updates to increase the completeness of the information and its scientific, social, and cultural usefulness.

The K-COM platform aims to create a digital space for exchange, meeting and comparison between local authorities and field experts. Its purpose is to develop ideas and projects with a positive innovative impact on social and economic development, also known as “Open Innovation”. This knowledge fruition mode is innovative because it promotes the creation of a learning community based on the “Open Community” model from which “Open Source” and “Open Content” concepts follow. The term “open” related to a community means that each one can contribute to the effort to enrich content and sources of the knowledge base. All community members collaborate in defining the direction and goals of team activities. It enhances shared knowledge and encourages circular communication. The peer-to-peer information flow allows the mutual check of the learning process, deriving from role reversal reciprocally between who learns and who produces content. This knowledge communication approach promotes comparing different users’ points of view, providing growth learning opportunities.

In this paper, firstly, the purposes of the project are presented, then the different steps of the K-COM development are illustrated, starting from the requirement analysis to web deployment. Finally, the focus is on future outcomes and new applications of the platform.

2. Application context and main goals

K-COM (Knowledge COMmunication) is a platform [3] based on web technologies, developed in the framework of the ES-PA project, which aims to improve the capacity of PA in public investment programs and multilevel governance.

The project main objective is to communicate comprehensive and practical knowledge on energy efficiency to technicians and public decision-makers through digital coaching. The OJT involves a personalised learning experience that can be tailored to the specific needs of the individual. This approach is designed to provide practical training that can be directly applied to real-world scenarios. By using digital coaching, participants can learn at their tread and in a way that is most effective for them. The platform's content aims to equip participants with the necessary skills and knowledge to make informed decisions about energy efficiency, which can significantly benefit their jobs.

The traditional training methodology is embedded within a digital space to make the learning process more effective and efficient, meeting users' needs. This approach allows for a streamlined process that imparts knowledge in a structured manner while maintaining flexibility in accommodating individual user requirements. By leveraging digital technologies in training, organisations can achieve better learning outcomes with reduced costs, faster turnaround times, and improved accessibility. This approach has become increasingly popular in modern business settings, as it offers a practical solution for delivering high-quality training that aligns with organisational goals and objectives.

In this digital space, a web community of expert technicians shares resources on a specific topic, including lessons, webinars, and texts. Users can conveniently access multiple resources, linked by keywords, in a single web space for quick consultation. This approach provides a streamlined and efficient way for users to gather information for their training.

The virtual community is open to all members, enabling a free and asynchronous flow of information that is useful in improving the skills of all participants. This openness ensures that knowledge is shared and that everyone benefits from it. Indeed, each community member simultaneously produces and uses the shared content. This twofold role makes the K-COM platform a digital hub for mutual professional growth and comparison for individuals and communities over time.

One of the benefits of open communities is that knowledge gained is not lost, but rather, it is retained and adapted to changes in time. It means that the community has a collective memory of what has worked and what has not. It can build upon this knowledge to improve future outcomes. By sharing knowledge and experiences openly, the community can capitalise on its collective intelligence and continuously innovate to meet new challenges. This approach to knowledge management allows for a more efficient use of resources and can ultimately lead to more successful outcomes.

The platform's design was developed through the following stages:

- application domain analysis in collaboration with experts in the field, taking into account available web technologies;
- users and system requirements definition;
- setting of the data model and the modular architecture by services;
- definition of a prototype with some use cases and application scenarios;
- final system design, with a web interface oriented towards the different user classes;
- usability test development is needed to highlight the goodness and limitations and allow further improvement of services and performances.

3. K-COM Matrix: topic, user class and type dimensions

The design of the K-COM platform began through a series of meetings with the commissioner to collect the training requirements concerning user classes and topics of interest. Usability has also been considered.

The specific topic identification is based on the regional top management and local administration needs, which, in turn, is to access a specific piece of information immediately or be deeply instructed in a particular topic.

Table 1 K-COM Matrix excerpt

User classes / *Topics*	User regional decision maker											
	WEB	VID	VIT	LEP	VIL	DOC	PPT	PPS	NEW	NOT	NOR	TOO
Climate change												
Mitigation							x	x	x		x	
Adaptation							x	x	x		x	
SECAP	x							x	x		x	
Energy efficiency technologies												
photovoltaic									x	x		
wind generator									x	x		
wall and roof green									x	x		
home automation									x	x		
thermal insulation									x	x		
biomass									x	x		
compost									x	x		
geothermal energy									x	x		
new materials									x	x		
solar heat									x	x		
Concentrated Solar Power									x	x		
Energy efficiency National Incentives												
65%	x						x				x	
eco-bonus/sisma-bonus	x						x				x	
Natural gas	x						x				x	
Conto energia	x						x				x	
Conto termico	x						x				x	
Fondo Naz. E.E.	x						x				x	
BIM		x	x				x	x	x		x	
Changing behaviour							x	x	x			
Indoor wellness							x	x	x			
NZEB	x	x					x	x	x		x	
Energy poverty	x	x					x	x	x			
APE							x	x	x		x	
SIAPE	x	x					x	x	x		x	
Energetic evaluation							x	x	x		x	
Energy Performance Contract		x	x				x	x	x		x	

Then, the gathered information is correlated through the "K-COM Matrix", Table 1 shows an excerpt related to one user class only (regional decision maker). It shows the relations between K-COM resources through *Topics, User Classes,* and *Contribution Type* (file type and format, detailed in Table 2) definitions.

Each *topic* has been categorised into two levels: the upper level is called "thematic", while the lower level is called "sub-thematic". For example, climate change is a thematic and mitigation and adaptation are its related sub-thematic.

The *user classes* include two professional sectors, the administrative and technical ones, covering two different governmental areas, regional and local. On an experimental basis, the user classes identified are:

- regional decision makers;
- local decision makers;
- regional or local technicians and officials;
- stakeholders;
- operators.

K-COM includes different supports for the contribution types, shown in Table 2, to meet the several learning modes. The selected resources belong to the following three macro-categories: audio, video and textual. Each has at least a predefined supported file format. Some webinars and video lectures are available in synchronous and asynchronous mode.

As another dimension, experts manually label each resource as basic, intermediate or advanced during content population. In detail, for each theme or topic in the matrix, it has been identified a "knowledge path" (KP), by collecting a set of heterogeneous (in type and format) resources called "knowledge object" (KO) and correlated by keywords. Each KO can be of only one file type at once from the mentioned Table 2.

This notion represents an entity that allows the user to operate autonomously. The connection between the system and the user is always synchronous; it can take place at any time and from anywhere and, therefore, integrates well with traditional learning processes.

In the K-COM environment, each notion concerns the creation of KP that focuses on specific technological and cultural themes to transfer information to recipients proactively and interactively. Each path may contain an indefinite number of KO.

Table 2 File type and Format

File type	Extension type	Symbol
Webinar	webinar	WEB
Technical application	zip rar tar	TOO
General Video	quicktime mpeg mp4	VID
Technical Video	quicktime mpeg mp4	VIT
Lecture in presence	quicktime mpeg mp4	LEP
Video Lecture	video_lez	VIL
Document (doc/pdf)	txt doc docx pdf	DOC
PPT Presentation	ppt pptx pdf	PPT
Scientific Publication	txt doc docx pdf	NEW
Report	txt doc docx pdf	NOT
Standard	txt doc docx pdf	NOR

Besides offering the best content for the user's needs, the platform expects:

- to help the user in content search through web-faceted or link searches;
- to suggest related content of interest.

4. K-COM Architecture

In art. 68 of the Italian Digital Administration Code [8], all public Italian administrations must use open source and free software, integrating economy and reuse principles. Thus, K-COM platform is a web application based on LAMP technologies (Linux / Apache / Middleware (PHP) / PostgreSQL). Figure 1 shows its general architecture.

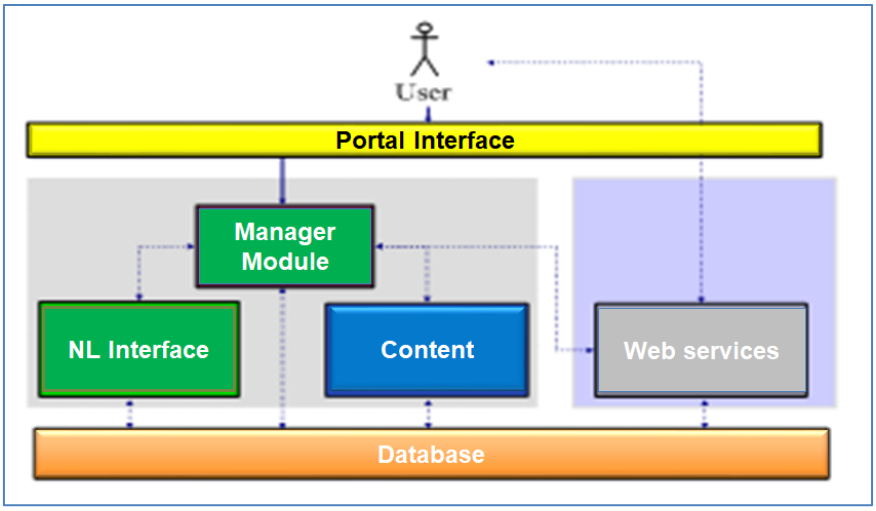

Figure 1 K-COM general architecture

The structure of the K-COM platform is organised on the "Card Manager" technology, where a database manages and retrieves information and data through the Manager Module (CORE). The final user accesses the content using a web interface that combines several types of Cards, the following section concerns the data modelling and retrieving, while Section 5 discusses the web interface design and Card models. The architecture includes a Natural Language (NL) module to support advanced data search: it will be a future platform development.

4.1. Data model

A relational database manages the metadata of knowledge resources, while the digital resources (files, images, audio, video, etc.) are referenced and accessed through the file system. Other promising approaches could be further investigated in the next version of this project, i.e., the use of a multimedia database or the representation of metadata through a graph database.

The database has been implemented in the Postgres 11.10-1 database with Postgis 3.0.3 extension. Postgres support for free text search has been exploited. Following the requirement analysis Section 3, a specific Entity-Relationships (ER) schema has been designed and subsequently transformed into a logical-physical model (both are reported in the technical report [1]).

Mainly, the domain entities are: Thematic, Sub-thematic, Knowledge Object, Knowledge Path, Author, User Class and Geographical Entities. A name and a description, plus, for Sub-thematic, the belonging thematic characterise the Thematic and Sub-thematic entities. KO refers to a specific Knowledge object acquired into the platform, which is the building block of any Knowledge Path. Besides the metadata of the multimedia resource and a descriptive name, the sub-thematic it refers to; moreover, it has been enriched with 5W question fields.

The 5W includes:

- a short description of the path or object (What);
- the validity time in years (When);
- the author who created this KP or KO (Who);
- the scope of supporting local entities (Why);
- the Italian municipality or local territory of belonging (Where).

A "knowledge path" (KP) is dynamically built from a set of heterogeneous (in type and format) KO, referring to a specific topic. After that, KOs are customised based on the users' level and geographical position, due to territory requirements, i.e. the regional body provides and regulates with calls and policy. The same KO can belong to multiple paths. Geographical entities are

municipality, province, and region. These are referenced and linked through the bijective ISTAT code, provided by the Italian National Institute of Statistics[2].

The system manages different types of users:

- content creator;
- system administrator;
- user for PA that accesses content.

The content creator uploads the KO and elaborates paths; he can also be its author or upload someone else resources. Each content creator has a preferred field of expertise but can also share knowledge in other fields.

The system administrator manages the other users, helps them solve problems of various matters, grants/revokes access to the platform, runs statistics and improves data stored in the database (e.g., adding further keywords, removing typos, etc.).

The user is generally a PA worker with two alternative classifications: decision-maker or operator; plus, he can have a further specification: technical or administrative. Depending on the user's role within the PA, if he is a decision-maker and is not interested in knowing resources on the operability of a specific issue.

4.2. Gold resources

The K-COM contents are *gold sources*, namely resources are manually made by domain experts, validated and properly annotated without bias. This manual process brings the availability of valuable gold KO, but simultaneously requires much effort. We plan to develop semi-automatic approaches to populate the resource, then ask for export human supervision to validate that only.

ENEA experts build knowledge paths through national data and repositories related to energy efficiency, made by technical resources, software (tool), technical guidelines, project reports, webinars, etc. Those resources have been uploaded to the platform by the content creators according to the K-com matrix.

The content will be produced and enriched dually, towards both top-down and bottom-up directions. In the top-down mode, the authors and the PA experts suggest new topics based on innovative, technological, and regulatory upgrades. The bottom-up mode concerns the survey of the different and emerging user interests through tools such as questionnaires and interviews. Moreover, when the resource requires further explanation or refers to a precise regulation, it includes the permalink provided by European and Italian official portals for current legislation.

4.3. Resources search: indexing and ranking

An advanced search function has been implemented for searching paths and knowledge objects. The goal is to generate well-defined paths with a limited number of objects to achieve the purpose.

K-COM supports two search modes:

- faceted search;
- keyword search.

Both approaches are implemented using SQL queries.

A faceted search will allow the user to search through data using facets that rely on the attributes of the resources (thematic, type, keywords, and so on) and the user's attributes (role, geographical

[2] ISTAT: www.istat.it

location, and interests). Based on the selected facet, the system gradually filters down a large data selection to a smaller one.

Keyword search allows searching content by specifying a set of keywords. Google spread the usage of keyword search engine, making this paradigm very popular. The keyword search engine requires resources indexed based on the related keywords employing an inverted index.

According to the database design, each resource is featured with at most three keywords manually selected by its creator; moreover, automatic keyword extraction has been implemented. The project exploits the Postgres full-text search functionalities[3] for automatic keyword extraction and keyword-based searches [9].

In particular, Postgres supports the tsvector type, the tsvector type represents a document in a form optimised for text search, in this work, this has been used to store textual fields and documents in the database; thus, it will be possible to index tsvector fields by using a Generalized Inverted Index (GIN Index in Postgres) and to search them by user searches converted into tsqueries. Several textual score metrics are available in PostgreSQL as functions used for ranking results; here, the term frequency of searched keywords is based on the boolean model.

Given a query description q containing $w_1 \ldots w_n$ keywords, for each textual field (*tf*) in the tuple *T*, we define the textual rank δ_w as:

$$\delta_w(q, T) = \sum_{i=1}^{n} \frac{p(w_i, tf(T))}{n}$$

where $p(w_i, tf\ (\mathrm{T}))$ equals 1 if the word w_i is present in any textual field of a tuple T at least once, 0 otherwise.

Thus, the resources with the highest δw are shown first when performing a keyword search.

Past research has discussed a similar approach [10] in considering temporal and geographical dimensions. Moreover, top-k strategies could be implemented to handle the queries efficiently [11] based on the relational structure of the data or its representation as a graph [12].

5. Interface Design and Validation

The K-COM platform front-end development exploits the latest technologies such as HTML5, CSS3, Bootstrap v3.3.7 library, JavaScript and jQuery library. The interface has the following features:

- responsiveness on different devices;
- user-friendly;
- accessibility[4] ([13]).

The main system design has been deployed to guarantee reliability, transparency, privacy, and security. Its services are monitored over time.

The platform has both public and private sections. The web interface allows three accesses: the administrator, the content creator, and the common users. The private area access requires registration and account activation, so the system administrator has to verify the eligibility, such as organisation (through the user email domain).

The authenticated user visualises or produces platform content through Cards.

A Card is a complex object (class) of a visual interface based on graphical objects to manage and query the database. In particular, the following Cards were managed in the platform: K Path Card, K Object Card and Document Card. Detail Card, accessory links recalled in correlation with the other content: Judgment Card, evaluation of the object.

[3]Postgres Text Search documentation: https://www.postgresql.org/docs/current/textsearch.html

[4] According to EU 2016/2102 and implemented to the Italian regulation with D.Lgs 10 August 2018, n. 106.

The Path Card concerns knowledge paths, i.e., the list of resources used in a given sequence can make one aware of a specific topic. As mentioned, the path can be combined with a series of Resource Cards.

The Document Card is a particular type of resource Card and only concerns the technical documentation relating to the software tools. The path may involve, for example, a specific theme and user. As mentioned, KP and KO are managed by employing a knowledge Card which must respond to the five "W" and the two "H", which respectively represent: Who, What, Where, When, Why, How and How Much (or How Many).

The PK Card pursues an Objective/Goal, while the KO Card defines the knowledge or notion frame available to the user. Both Cards deal with meanings and can also be managed in STACK format; that is, they can be grouped in a general list or for various lists differentiated by theme or topic and by goal. To facilitate the management, querying and viewing of the data, it is possible to navigate from one Card to another based on their relationship, or from a Master Card to a more detailed one.

When the user is a content creator, she can upload and describe the content, namely KO and KP, filling the Card. The current version of the interface does not support the user assigning an already created KO inside a new KP, but this is supported by the data model and the inner structure of the database and will be implemented in the interface in a future version.

The main end-user functionalities are user registration (manager, end-user), KO and KP management, documents management, advanced K resource search, presentation and use of advanced tools for energy efficiency.

The advanced search consists of faceted and keyword searches, presented in the previous section and may include a geographic location. For example, the end-user living in the Veneto Region could ask the K-COM platform about the agrivoltaic installations, and the system will show the correlated KO resources only if she selects the right region in the specific theme (based on [14]). Retrieved resources come with a KO Card that intuitively reports all related metadata.

A KO Card, as shown in Figure 2, highlights the areas of content, links to similar content, user rating, difficulty level, validity, documentation, keywords and knowledge parameters. Contextually, a chat related to the subject allows the user to ask questions and to have "predefined" answers added by the expert user.

Indeed, in the Card, almost every structured information (the type of the resource, the authors, the main keywords, the thematic and so on) are links and the user, by selecting the link, for example, holding the type of resource, will immediately access to other resources of the same type. Link search is indeed an alternative graphical interface for performing faceted searches.

On the right side of the Card, there are resources shown to the users that have commonalities (type, authors, thematic, keywords) with the currently selected resource or the user's interests.

The main area of interest is one of the main features used for personalising the content suggested to the users.

In the internal environment, the users can experiment with a deep interaction with the system. For example, when a retrieved resource is a seminar or video lecture, it is directly managed within the ENEA NetSeminar system, see Figure 3.

Figure 2 Knowledge Object Card

Figure 3 (a) left figure shows the K-COM Advanced Searching form while the (b) right figure shows the visualisation of the found resource (Climate change strategies).

The other systems integrated, employing interoperability functions, with K-COM are:

- Matrix Platform VI Generation manages, using a web visual representation, the e-learning courses; K-COM has been integrated with the Matrix e-learning platform through specific tags, represented by icons, inserted in the course lesson texts and video lessons to navigate towards the KO Cards. The system was integrated with a series of existing hypertext courses, video lessons and webinars in high definition (Full HD) and documents managed by a multimedia database [15].
- NetLesson 22 [16] and NetSeminar 22 manage the video lectures and webinar using a visual interface based on video and synchronised slide presentation;
- Mobile QS 21 [17]manages the interaction with the query system application in a mobile context, using an ultimate generation of smartphones;
- SIMTE Web platform manages the visualisation of brief papers collected by simple links.

The platform development follows an iterative and recursive model, in which the evaluation of core functionalities through testing activities has assumed a central role in understanding its degree of usability [18]. End-users and experts have carried out specific experiments to test K-COM in terms of functionality and contents, and these have revealed the platform to be easily usable even for non-technical users. The most significant tasks concerned the management of a K Path and related K Objects. The inquiry of a KP and its KO with total visualisation and reading of the information and the data presented. Finally, selecting and using an Energy Efficiency application is a more complex task. Details on the testing process are reported in the technical report [1].

6. Conclusions and future works

The K-COM (Knowledge COMmunication) platform is a digital space for the exchange, meeting and discussion of energy efficiency issues within the community of expert users in the field, so it is designed to store and disseminate technical knowledge. It aims to provide On-the-Job Training (OJT) to Public Administration (PA) users interested in energy efficiency issues, through Open Community support.

In this way, the Open Community growth is encouraged. In these communities, everyone can join and contribute with their scientific background cooperating to Open Source and Content dissemination. To achieve this goal, the platform's development has made it necessary to manage Open data and analyse information related to the energy efficiency sector.

The digital library resources in the platform are grouped into Knowledge Objects (KO) that are part of specific Knowledge Pathways (KP). Each KO is a resource of a different type (audio, video, textual) placed within a specific KP and identified by an information card (Card). Its modular architecture enabled the deployment of a dynamic system, allowing the continuous upgrade of obsolete objects. So, bi-directional communication has been enabled through a highly usable interface that has been rigorously tested using specific tests.

So, the powered informative system is more complete with the possibility of adding new knowledge paths, increasing its scientific, social, and cultural usefulness.

The platform’s future developments will concern the expansion of knowledge paths with general topics that are not necessarily related to energy efficiency, eventually developing a semi-automatic approach for populating the paths under human supervision. The knowledge paths and objects can be customised based on users' geo-referenced profiling, resulting in a more personalised experience for each user.

Finally, an advanced meta-engine powered by Artificial Intelligence will be able to process complex search requests in natural language, including voice-to-text and text-to-voice capabilities.

Additionally, it will be possible to incorporate intelligent features to manage new content in real time under the supervision of a human expert user.

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